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A Nationwide Inventory of Emissions of Air Contaminants (1978)

Economic and Technical Review
Report EPS 3-EP-83-10

Environmental Protection Programs Directorate
December 1983

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A NATIONWIDE INVENTORY OF EMISSIONS OF AIR CONTAMINANTS (1978)

Program Management Branch
Environmental Protection Programs Directorate
Environmental Protection Service
Environment Canada

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ABSTRACT

Atmospheric emissions of particulate matter, sulphur oxides, nitrogen oxides, hydrocarbons and carbon monoxide from various Canadian sources have been estimated for the year 1978. During 1978, about 2.3 million tonnes of particulates, 4.5 million tonnes of sulphur oxides, 1.9 million tonnes of nitrogen oxides, 2.2 million tonnes of hydrocarbons and 9.8 million tonnes of carbon monoxide were released to the atmosphere. Industrial processes are the major source of particulate and sulphur oxide emissions, whereas nitrogen oxide, hydrocarbon and carbon monoxide emissions are predominantly from transportation sources.

Forest fires and mining operations each accounted for about 19% of the total particulate emissions. Sulphur oxide emissions come primarily from primary copper and nickel smelting (38.0% of total) and electric power generation (16.3% of total). Nitrogen oxide emissions are mainly from gasoline-powered motor vehicles (25.6% of total), diesel powered engines (23.9% of total) and electric power generation (12.7% of total). Gasoline-powered motor vehicles are important sources of hydrocarbon emissions (31.5% of total). Gasoline powered motor vehicles are also major contributors of carbon monoxide emissions (60.0% of total).

Five geographical maps of Canada are provided, illustrating the emission densities for each contaminant on a 127 km by 127 km grid. Emissions of the five contaminants from each source surveyed have been further broken down on a provincial basis.

The five contaminants inventoried are the most significant from a quantitative point of view. Particulates are emitted in a wide range of compositions and sizes and their release is often subject to some form of control. Although emissions of sulphur oxides may be controlled, this is seldom the case for the other three contaminants (with the notable exception of pollution control devices on recent model motor vehicles).

Direct comparison between this report and a previous report entitled "A Nationwide Inventory of Emissions of Air Contaminants (1976)" is not advisable because of the variation in approaches in determining emissions from specific sectors. As more and better information is received, the accuracy of the emissions estimates improves.

For the first time, emissions of fugitive dusts (defined as open sources) have been inventoried and the results are summarized. Using available published methods for computing emissions from these sources, preliminary indications are that approximately 40 million tonnes of particulate matter are emitted into the atmosphere annually.

RÉSUMÉ

On a évalué les émissions atmosphériques de particules, d'oxydes de soufre, d'oxydes d'azote, d'hydrocarbures et de monoxyde de carbone provenant de diverses sources, au Canada, en 1978. En 1978, 2,3 millions de tonnes de particules, 4,5 millions de tonnes d'oxydes de soufre, 1,9 million de tonnes d'oxydes d'azote, 2,2 millions de tonnes d'hydrocarbures et 9,8 millions de tonnes de monoxyde de carbone ont été rejetées dans l'atmosphère. C'est l'industrie qui a été la principale source de particules et d'oxydes de soufre, tandis que les moyens de transport ont surtout donné lieu aux émissions d'oxydes d'azote, d'hydrocarbures et de monoxyde de carbone.

Les incendies de forêts ainsi que l'exploitation minière représentent chacun 19 % du total des émissions de particules. Les émissions d'oxydes de soufre sont principalement attribuables aux fonderies de cuivre et de nickel de première fusion (38,0 % du total) ainsi qu'aux centrales thermiques (16,3 % du total). Les émissions d'oxydes d'azote provenaient surtout des moteurs à essence (25,6 % du total), des moteurs à diesel (23,9 % du total) ainsi que des centrales thermiques (12,7 % du total). Les véhicules à moteur à essence ont été d'importantes sources d'hydrocarbures (31,5 % du total), ainsi que de monoxyde de carbone (60,0 % du total).

On a inséré cinq cartes du Canada, une pour chacun des polluants, où on montre la densité des émissions sur une grille dont les carreaux représentent 127 km sur 127 km. Les émissions de chaque source étudiée ont, de plus, fait l'objet d'une compilation à l'échelle provinciale.

Les cinq polluants inventoriés sont les plus importants pour le tonnage émis. Les particules émises varient grandement en grosseur et en composition et elles sont souvent soumises à un traitement quelconque. Les oxydes de soufre peuvent également être interceptés de façon similaire. Toutefois, les trois autres polluants le sont rarement, sauf dans les voitures de modèle récent, munies d'un dispositif antipollution.

On évitera de comparer les données du présent rapport avec celles de l'"Inventaire national des rejets de polluants dans l'atmosphère (1976)" étant donné que les méthodes utilisées pour calculer les émissions provenant des divers secteurs diffèrent. L'exactitude des estimations croît en raison du nombre et de la qualité des renseignements de base.

On a inventorié pour la première fois les émissions de poussières de sources étendues, et les résultats sont résumés. Selon les méthodes publiées pour calculer les émissions provenant de ces sources, quelque 40 millions de tonnes de particules seraient émises chaque année dans l'atmosphère.

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SUMMARY

Atmospheric emissions of particulate matter, sulphur oxides, nitrogen oxides, hydrocarbons and carbon monoxide from various Canadian sources have been estimated for the year 1978.

Emission totals for the five major contaminants for five main source categories are presented in Table 1. During 1978, about 2.3 million tonnes of particulates, 4.5 million tonnes of sulphur oxides, 1.9 million tonnes of nitrogen oxides, 2.2 million tonnes of hydrocarbons and 9.8 million tonnes of carbon monoxide were released to the atmosphere. Industrial processes are the major source of particulate and sulphur oxide emissions, whereas nitrogen oxide, hydrocarbon and carbon monoxide emissions are predominantly from transportation sources.

TABLE 1 NATIONWIDE EMISSIONS OF AIR CONTAMINANTS, 1978

	Emissions (tonnes x 10^3)									
Category	Particulate matter	% of total	Sulphur oxides*	% of total	Nitrogen oxides**	% of total	Hydro-carbons	% of total	Carbon monoxide	% of total
Industrial processes	1 298	56.4	2 786	62.2	50	2.7	580	27.0	1 072	11.0
Fuel combustion/ stationary sources	279	12.2	1 545	34.5	658	35.6	119	5.6	303	3.1
Transportation	92	4.0	143	3.2	1 115	60.2	851	39.6	7 245	74.3
Solid waste incineration	36	1.6	3	0.1	5	0.3	31	1.4	376	3.9
Miscellaneous	592	25.8	-	-	22	1.2	567	26.4	755	7.7
TOTAL	2 298	100.0	4 477	100.0	1 850	100.0	2 149	100.0	9 751	100.0

* Expressed as SO_2
** Expressed as NO_2

A detailed breakdown of emissions of the five contaminants on a source-by-source basis is given in Table 2. Forest fires and mining operations each account for about 19% of the total particulate emissions. Sulphur oxide emissions come primarily from primary copper and nickel smelting (38.0% of total) and electric power generation (16.3% of total). Nitrogen oxide emissions are mainly from gasoline-powered motor vehicles (25.6% of total), diesel powered engines (23.9% of total) and electric power generation (12.7% of total). Gasoline-powered motor vehicles are important sources of hydrocarbon emissions (31.5% of total). Gasoline powered motor vehicles are also major contributors of carbon monoxide emissions (60.0% of total).

Five geographical maps of Canada have been included, one for each contaminant, illustrating the emission densities of the contaminants on a 127 km by 127 km grid. These maps provide a snap-shot view of the magnitude and distribution of the emissions in Canada and appear after page xviii.

Emissions of the five contaminants from each source surveyed have been further broken down on a provincial basis and are shown in Appendix A.

The five contaminants inventoried are the most significant from a quantitative point of view. Particulates are emitted in a wide range of compositions and sizes and their release is often subject to some form of control. Although emissions of sulphur oxides may be controlled, this is seldom the case for the other three contaminants (with the notable exception of pollution control devices on recent model motor vehicles).

Direct comparison between this report and a previous report entitled "A Nationwide Inventory of Emissions of Air Contaminants (1976)" is not advisable because of the variation in approaches in determining emissions from specific sectors. As more and better information is received, the accuracy of the emissions estimates improves. Thus, any comparison may mislead the reader in interpreting the actual change of air pollution levels in Canada between 1976 and 1978.

For the first time, emissions of fugitive dusts (defined as open sources) have been inventoried and the results are summarized in Appendix B. Using available published methods for computing emissions from these sources, indications are that approximately 40 million tonnes of particulate matter are emitted into the atmosphere on an annual basis. These estimates are regarded as preliminary and have not been included in the main body of the report nor in the emission summary tables.

TABLE 2 NATIONWIDE EMISSIONS OF AIR CONTAMINANTS, BY SOURCE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	140 169	151 550	-	-	38 104
Pyrrhotite roasting	2 619	31 561	-	-	-
Iron and steel production	75 782	11 089	-	-	254 756
Primary aluminum production	57 194	52 086	8 403	1 448	146 691
Primary copper and nickel production	49 235	1 707 424	-	-	-
Copper and nickel refining	2 047	833	-	-	-
Primary lead and zinc production	8 518	51 490	-	-	-
Ferroalloy manufacture	25 369	1 782	-	-	15 754
Abrasives manufacture	7 531	7 873	-	-	6 724
Ferrous foundries	12 062	-	-	-	6 715
Magnesium production	329	-	-	-	-
Asbestos production	76 825	-	-	-	-
Mining and rock quarrying	192 809	-	-	-	-
Salt production	10 143	-	-	-	-
Lime manufacturing	29 050	-	-	-	-
Gypsum processing	19 536	-	-	-	-
Nepheline syenite processing	460	-	-	-	-
Potash processing	22 802	-	-	-	-
Silica processing	1 069	-	-	-	-
Stone processing	36 203	-	-	-	-
Sand and gravel processing	13 299	-	-	-	-
Cement manufacture	47 761	-	-	-	-
Concrete batching	2 207	-	-	-	-
Asphalt production	64 258	-	-	-	-
Glass manufacturing	1 410	-	-	-	-

TABLE 2 NATIONWIDE EMISSIONS OF AIR CONTAMINANTS, BY SOURCE, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Clay products manufacture	12 722	-	-	-	-
Crude oil production	-	-	-	28 [illegible]34	-
Petroleum refining	12 519	93 214	4 743	185 934	421 274
Natural gas processing	-	434 891	-	2 348	-
Tar sands operations	9 606	107 600	13 653	9	210
Coal industry	79 465	-	-	153 806	-
Metallurgical coke manufacture	19 951	7 760	23	1 628	1 543
Petrochemical Industry	-	-	-	168 926	-
Plastics Fabrication	-	-	-	19 763	-
Carbon black	18	2 490	-	111	161 061
Sulphuric acid production	-	17 899	-	-	-
Nitric acid production	-	-	6 944	-	-
Phosphoric acid production	71	-	-	-	-
Phosphate rock processing	415	-	-	-	-
Phosphate fertilizer manufacture	4 301	-	-	-	-
Elemental phosphorus production	10 675	2 115	-	-	-
Nitrate fertilizer manufacture	6 697	-	170	-	-
Grain handling and milling	65 050	-	-	-	-
Bakeries	-	-	-	3 749	-
Sulphate (kraft) pulping	105 720	35 241	16 500	12 755	19 502
Sulphite pulping	1 442	69 070	-	-	-
Sawmills	61 000	-	-	-	-
Pulpboard manufacture	1 770	-	-	142	-
Plywood and Veneer	8 327	-	-	294	-
Subtotal	1 298 436	2 785 968	50 436	580 367	1 072 334

TABLE 2 NATIONWIDE EMISSIONS OF AIR CONTAMINANTS, BY SOURCE, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
FUEL COMBUSTION/STATIONARY SOURCES					
Power generation by utilities	163 220	730 558	236 925	4 855	17 321
Residential fuel combustion	8 739	102 488	45 910	4 762	19 667
Industrial fuel combustion	59 324	603 243	320 134	49 808	29 071
Commercial fuel combustion	9 476	108 643	49 108	1 884	6 527
Fuelwood combustion	38 334	-	5 749	57 500	230 002
Subtotal	279 093	1 544 932	657 826	118 809	302 588
TRANSPORTATION					
Gasoline-powered motor vehicles	42 806	18 776	474 089	677 042	5 850 522
Railroads	6 903	32 468	101 433	25 358	36 886
Marine	4 665	48 090	26 331	29 778	71 400
Aircraft	1 430	2 284	38 006	9 094	87 287
Off-road use of gasoline	1 958	1 473	31 528	55 870	1 051 358
Diesel-powered engines	31 085	40 176	443 237	53 082	147 329
Tire wear	3 340	-	-	668	-
Subtotal	92 187	143 267	1 114 624	850 892	7 244 782
SOLID WASTE INCINERATION					
Municipal incineration	4 976	1 366	1 542	777	18 502
Industrial and commercial incineration	1 110	666	725	222	801
Sewage sludge incineration	133	585	184	47	-
Wigwam burners	30 180	275	2 744	30 180	356 695
Subtotal	36 399	2 892	5 195	31 226	375 998

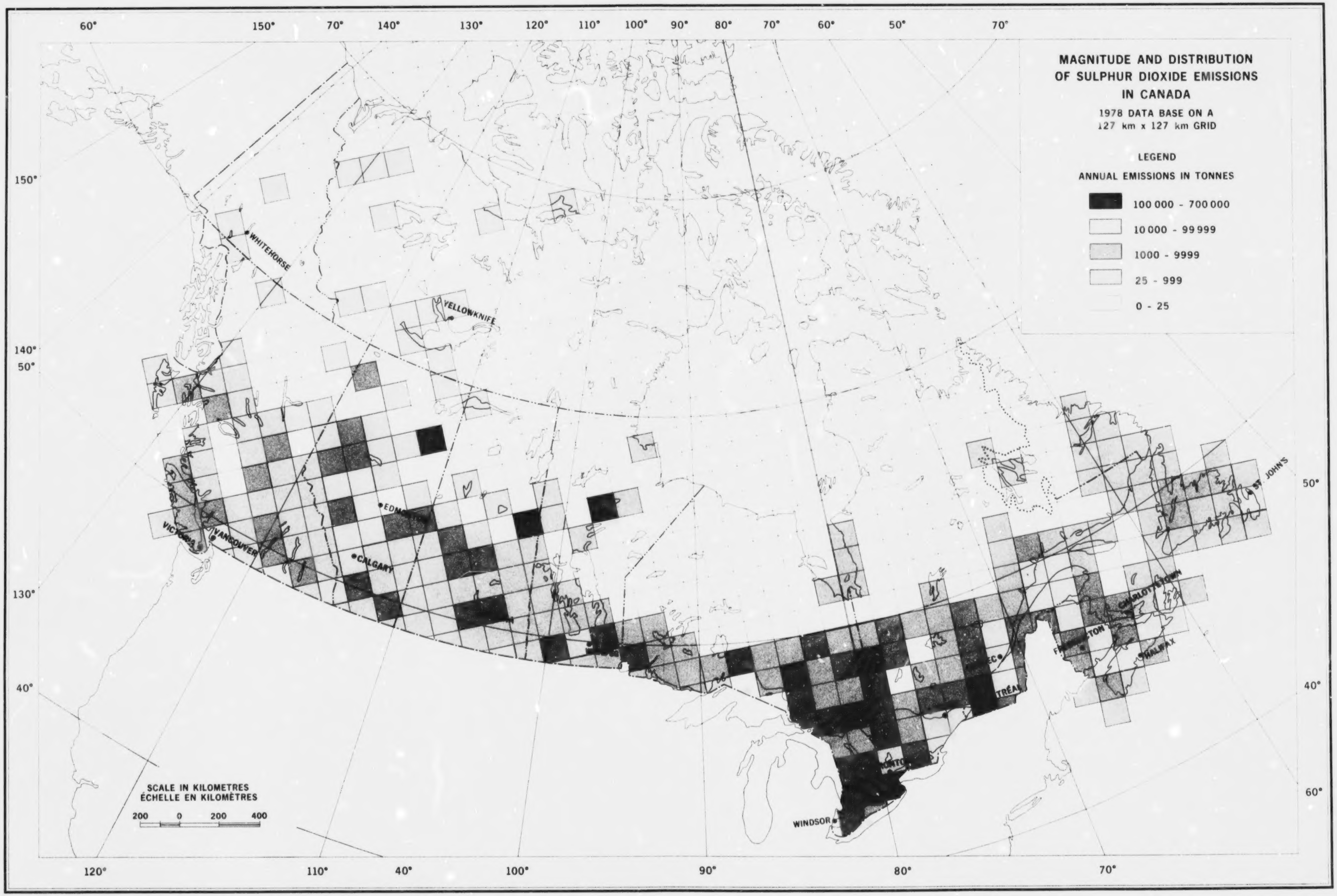
TABLE 2 NATIONWIDE EMISSIONS OF AIR CONTAMINANTS, BY SOURCE, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
MISCELLANEOUS					
Fertilizer application	6 910	-	-	-	-
Pesticide manufacturing and application	26 716	-	-	-	-
Gasoline and diesel marketing	-	-	-	234 450	-
Dry cleaning	-	-	-	15 876	-
Application of surface coatings	-	-	-	128 429	-
Structural fires	6 777	-	-	6 777	13 552
Cigarette smoking	4 313	-	-	-	1 726
General Solvents Use	-	-	-	72 427	-
Landfill Sites	-	-	-	15 437	-
Forest Fires	463 509	-	12 361	74 160	494 410
Slash Burning	83 550	-	9 831	19 659	245 739
Subtotal	591 775	-	22 192	567 215	755 427
TOTAL	2 297 890	4 477 059	1 850 273	2 148 509	9 751 129

* Expressed as SO_2

** Expressed as NO_2

FIGURE 1

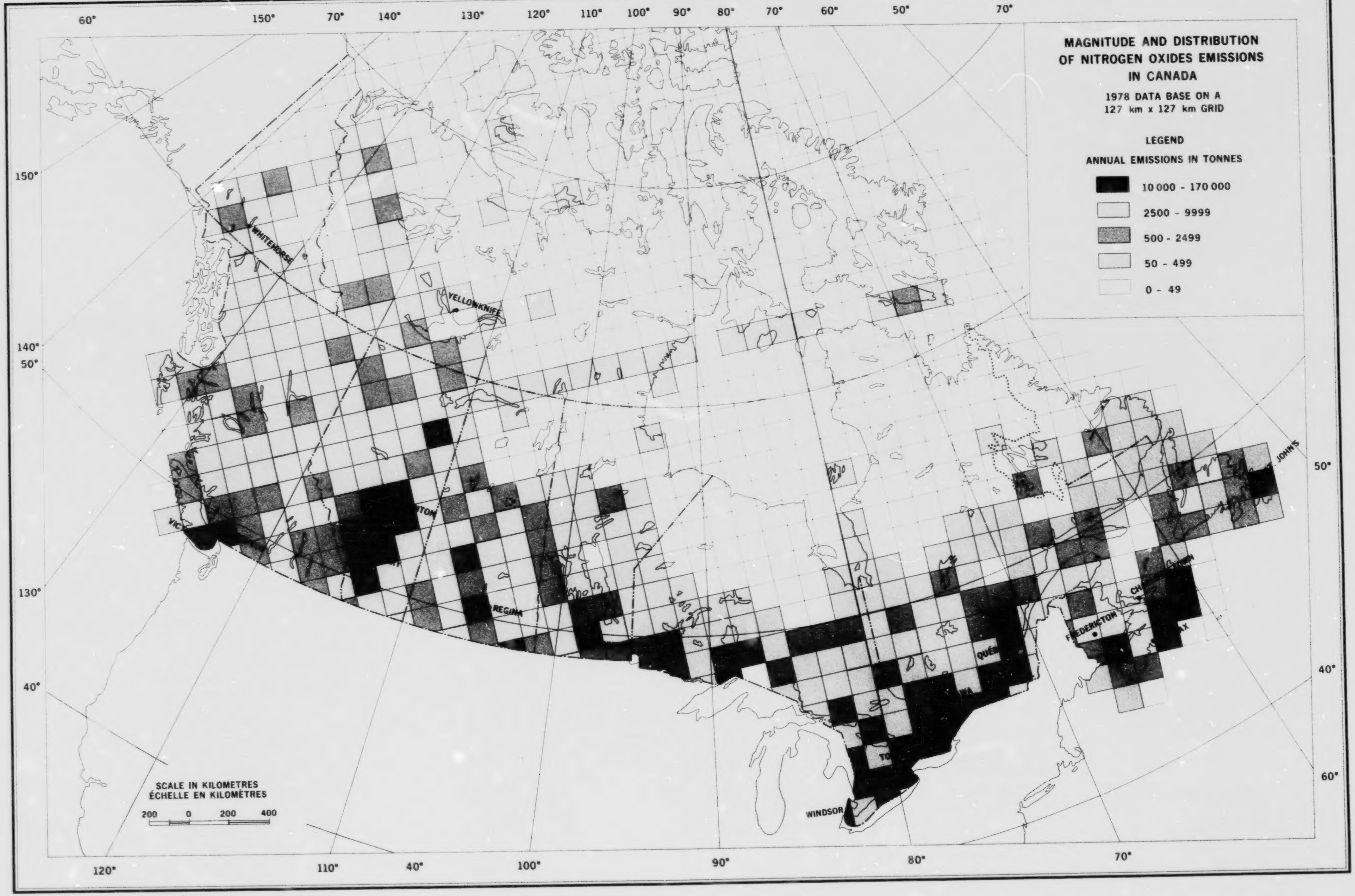


MAGNITUDE AND DISTRIBUTION OF SULPHUR DIOXIDE EMISSIONS IN CANADA

1978 DATA BASE ON A 127 km x 127 km GRID

LEGEND
ANNUAL EMISSIONS IN TONNES
100 000 - 700 000
10 000 - 99 999
1000 - 9999
25 - 999
0 - 25
WHITEHORSE
YELLOWKNIFE
EDMONTON
CALGARY
VICTORIA
VANCOUVER
WINDSOR
TORONTO
MONTRÉAL
QUEBEC
FREDERICTON
CHARLOTTETOWN
HALIFAX
ST. JOHN'S
SCALE IN KILOMETRES
ÉCHELLE EN KILOMÈTRES
200
0
200
400
60°
150°
70°
140°
130°
120°
110°
100°
90°
80°
70°
60°
50°
70°
150°
140°
50°
130°
40°
50°
40°
60°
120°
110°
40°
100°
90°
80°
70°

FIGURE 2

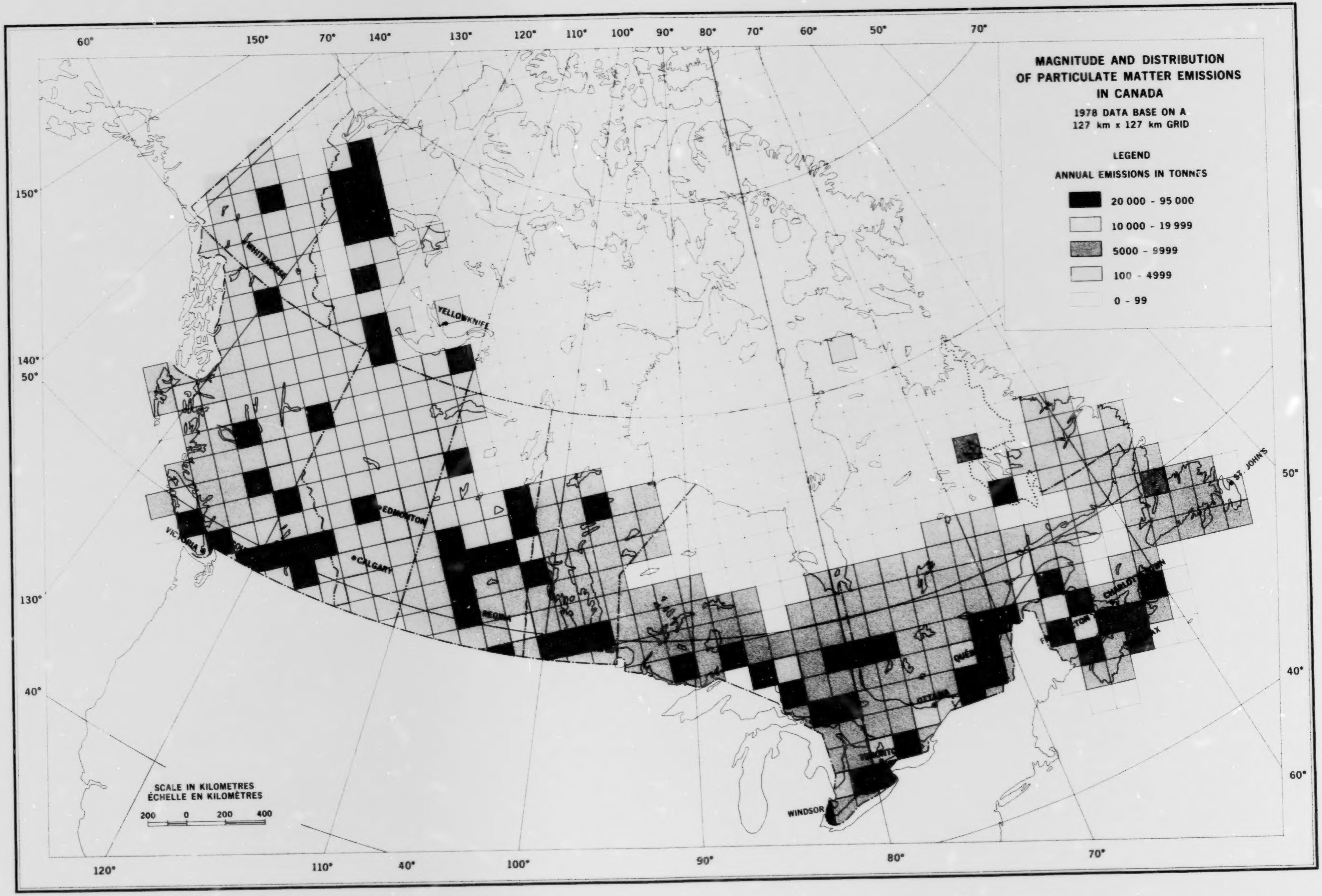


MAGNITUDE AND DISTRIBUTION OF NITROGEN OXIDES EMISSIONS IN CANADA

1978 DATA BASE ON A 127 km x 127 km GRID

LEGEND
ANNUAL EMISSIONS IN TONNES
■ 10 000 - 170 000
▨ 2500 - 9999
▨ 500 - 2499
□ 50 - 499
□ 0 - 49
WHITEHORSE
YELLOWKNIFE
VIC
TON
REGINA
QUÉ
WA
TO
WINDSOR
FREDERICTON
CH
JOHNS
AX
SCALE IN KILOMETRES
ÉCHELLE EN KILOMÈTRES
200
0
200
400
60°
150°
70°
140°
130°
120°
110°
100°
90°
80°
70°
60°
50°
70°
150°
140°
50°
130°
40°
50°
40°
60°
120°
110°
40°
100°
90°
80°
70°

FIGURE 3

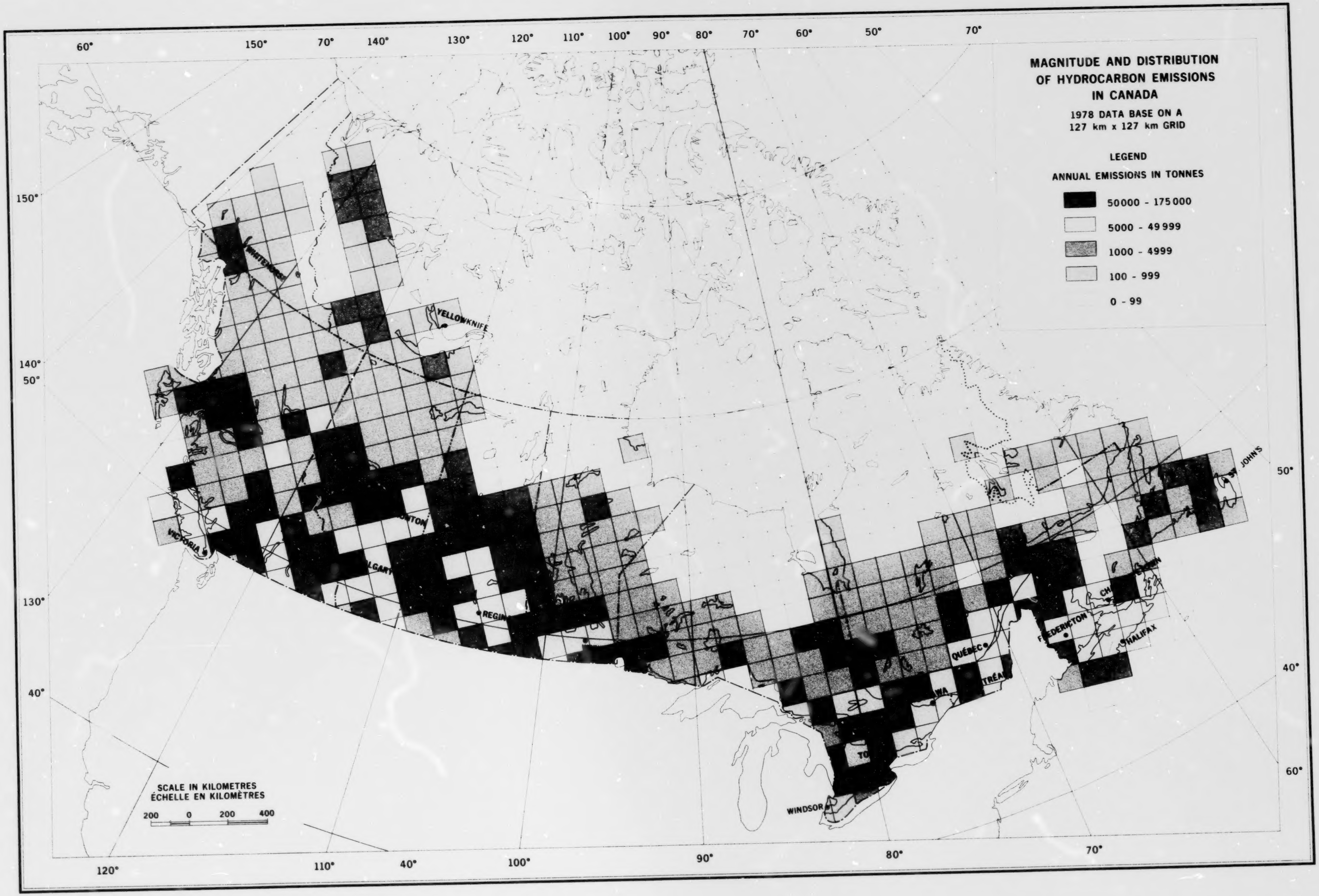


MAGNITUDE AND DISTRIBUTION OF PARTICULATE MATTER EMISSIONS IN CANADA

1978 DATA BASE ON A 127 km x 127 km GRID

LEGEND
ANNUAL EMISSIONS IN TONNES
20 000 - 95 000
10 000 - 19 999
5000 - 9999
100 - 4999
0 - 99
WHITEHORSE
YELLOWKNIFE
EDMONTON
CALGARY
VICTORIA
REGINA
QUÉBEC
OTTAWA
TORONTO
WINDSOR
FREDERICTON
CHARLOTTETOWN
HALIFAX
ST. JOHN'S
SCALE IN KILOMETRES
ÉCHELLE EN KILOMÈTRES
200
0
200
400
60°
150°
70°
140°
130°
120°
110°
100°
90°
80°
70°
60°
50°
70°
150°
140°
50°
130°
40°
120°
110°
40°
100°
90°
80°
70°
50°
40°
60°

FIGURE 4

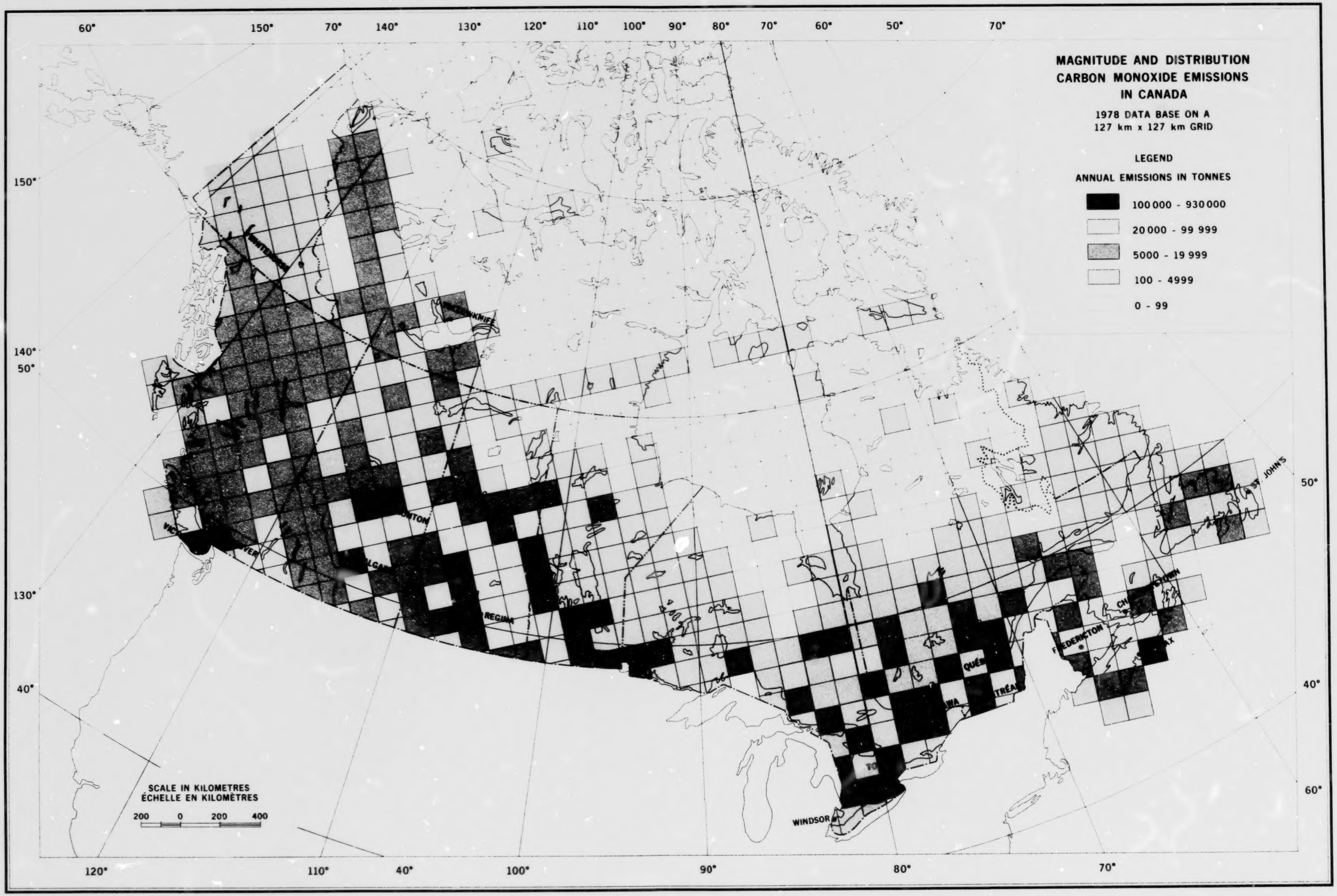


MAGNITUDE AND DISTRIBUTION OF HYDROCARBON EMISSIONS IN CANADA

1978 DATA BASE ON A 127 km x 127 km GRID

LEGEND
ANNUAL EMISSIONS IN TONNES
■ 50000 - 175000
▨ 5000 - 49999
▨ 1000 - 4999
□ 100 - 999
0 - 99
SCALE IN KILOMETRES
ÉCHELLE EN KILOMÈTRES
200
0
200
400
WHITEHORSE
YELLOWKNIFE
VICTORIA
CALGARY
EDMONTON
REGINA
WINDSOR
TORONTO
OTTAWA
MONTRÉAL
QUÉBEC
FREDERICTON
CHARLOTTETOWN
HALIFAX
ST. JOHN'S
60°
150°
70°
140°
130°
120°
110°
100°
90°
80°
70°
60°
50°
70°
150°
140°
50°
130°
40°
50°
40°
60°
120°
110°
40°
100°
90°
80°
70°

FIGURE 5



MAGNITUDE AND DISTRIBUTION CARBON MONOXIDE EMISSIONS IN CANADA

1978 DATA BASE ON A 127 km x 127 km GRID

LEGEND
ANNUAL EMISSIONS IN TONNES
■ 100 000 - 930 000
☐ 20 000 - 99 999
▨ 5000 - 19 999
☐ 100 - 4999
0 - 99
SCALE IN KILOMETRES
ÉCHELLE EN KILOMÈTRES
200
0
200
400
60°
150°
70°
140°
130°
120°
110°
100°
90°
80°
70°
60°
50°
70°
150°
140°
50°
130°
40°
50°
40°
60°
120°
110°
40°
100°
90°
80°
70°
WHITEHORSE
YELLOWKNIFE
VIC
VER
ONTON
ALGA
REGINA
WINDSOR
TO
WA
TRÉA
QUÉ
FREDERICTON
CH
ETOWN
AX
ST. JOHN'S

1 INTRODUCTION

1.1 Scope

The purpose of this report is to identify and quantify sources of atmospheric emissions of the five primary air contaminants, in terms of source categories, for the year 1978. The contaminants considered are particulate matter, sulphur oxides, nitrogen oxides, hydrocarbons and carbon monoxide. Emissions are determined on a provincial basis in this report; however, more detailed information on a census division or on a 127 km x 127 km grid basis is available from the Program Management Branch.

A previous report entitled "A Nationwide Inventory of Emissions of Air Contaminants, 1976" (Report EPS 3-AP-80-1) was updated using 1978 information to produce this report. Direct comparison between the two reports is not advisable because a number of new sources have been inventoried tending to increase emission totals; however emission trends will be available at a later date. In addition, changes in emissions not attributable to trends have resulted from the use of better and more reliable information. The inventory is to be updated every two years and over a period of time it should reflect such factors as the impact of air pollution control legislation, changes in fuel use by consumers and trends in manufacturing activity.

1.2 Methodology

In assessing air pollution on a national level, accurate data on the quantity and characteristics of emissions from all sources contributing to the problem are required. The large number of sources and the diversity of source types make it impracticable to conduct emission testing on a source-by-source basis at the point of release.

As much information as possible has been extracted from replies to various questionnaires sent to individual companies over the previous few years. Where such firsthand data were not available, it was necessary to adopt the 'emission factor' approach.

The emission factor is a statistical average of the rate at which a contaminant is released to the atmosphere as a result of some activity, such as combustion or industrial production, divided by the level of that activity. The emission factor, therefore, relates the quantity of each contaminant emitted to an appropriate 'base' quantity such as production or quantity of fuel burned. The source of most emission factors employed in this report is the "Compilation of Air Pollutant Emission Factors", published by the U.S. Environmental Protection Agency (1977). Where available, emission factors developed for Canadian conditions by the Air Pollution Control Directorate were used. Occasionally, only engineering estimates were available.

Information regarding production and fuel consumption by the various sources was usually obtained from either Statistics Canada or the Department of Energy, Mines and Resources. This was supplemented by data published by a number of industrial associations, and by information from other federal government departments, provincial government agencies, and in some cases by industry.

Emissions have been estimated for different source types. Each source type is dealt with separately in the following pages by a brief outline of the process, emission sources, controls and methodology used to estimate emissions.

The previous inventory contained a separate section on particulate emissions from unpaved roads. Given the magnitude of these emissions (and preliminary nature of the results), this sector was excluded from the main summary tables so as not to dwarf the other emissions. For the 1978 inventory, several sectors have been added to the open source emissions and are again treated separately in Appendix B. Open sources are defined as emission sources that cover large geographical areas, are exposed to the natural elements, and cannot be controlled through enclosure and ducting. These sources should not be confused with natural sources of emissions since they exist primarily as a result of the activities of man. Open source emissions were not previously considered, with the exception of unpaved roads. They have been included in this publication because inventory techniques have been published in this area. They have also become significant in the development of more detailed inventories (e.g., urban inventories) and the investigation of source-receptor relationships.

This inventory also includes for the first time particulate fugitive emissions which were not previously separated from the traditional point source emissions. Fugitive emissions are defined as emissions bypassing off-gas containment and control equipment and which enter the atmosphere through no specific point, such as a stack. Due to the lack of scientific data, fugitive emissions for the other four contaminants were not considered.

2 INDUSTRIAL EMISSIONS

2.1 Iron Ore Mining and Beneficiation

2.1.1 Process Description. Iron ore is mined by either open-pit or underground methods and transported to a beneficiation plant. Some ores can be concentrated simply by crushing, screening, blending and washing; others require grinding and subsequent separation of the iron from other materials by flotation or magnetic separation. Concentrated ores are then agglomerated by sintering or pelletizing to produce suitably sized blast furnace feed. Pelletizing is usually done near the mine site, whereas sintering is performed at the steel mill. Only one plant in Canada sintered iron ore at the mine in 1978.

2.1.2 Emission Sources. Emissions resulted mainly from mining, crushing, grinding, pelletizing and sintering operations. Of total emissions, those from mining operations represented the largest portion and consisted mainly of fugitive dust and other particulate matter. Sulphur oxides and carbon monoxide were also released during sintering operations.

2.1.3 Controls. Emissions from mining operations were assumed to be uncontrolled. Crushing operations are controlled mainly by high efficiency cyclones, whereas grinding is an all-wet process, with negligible emissions. Overall efficiency for these two processes is assumed to be 70%. An overall 54% control efficiency was estimated for pelletizing plants by assuming a 90% control at 60% of the installations, whereas the sintering operation was controlled by cyclones with 70% efficiency (1).

2.1.4 Emissions. Emissions from open-pit mining and underground mining were considered. The quantity of ore mined by open-pit methods in 1978 was estimated from pertinent information (2). Only one sinter plant was included in this sector because all other sintering operations were carried out at integrated iron and steel plants. Emission factors for open-pit and underground iron ore mining were considered to be the same as those for other open-pit and underground metal mines, respectively, since similar operations are involved. Emission information for crushing and grinding and pelletizing operations was taken from internal data, where available (3). All other emissions (except SO_2 sintering emissions) were calculated using emission factors from U.S. Environmental Protection Agency publications (4, 5). Sulphur dioxide emissions from sinter plants were obtained from various sources (6, 7).

Emission factors and total emissions for iron ore mining and beneficiation are presented in Tables 3 and 4, respectively.

TABLE 3 UNCONTROLLED EMISSION FACTORS, IRON ORE MINING AND BENEFICIATION

	Emission factors (kg/tonne of ore)		
Operation	Particulate matter	Sulphur oxides (as SO_2)	Carbon monoxide
Open-Pit Mining	0.51		
Underground Mining	0.05		
Crushing and grinding	1.0		
Pelletizing[a]	5.6		
Sintering[b]	21.0	c	22.0

a Emission factor expressed as kg/tonne of pellets
b Emission factor expressed as kg/tonne of sinter
c Calculated from specific plant data

TABLE 4 TOTAL EMISSIONS, IRON ORE MINING AND BENEFICIATION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	48 570				
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec	59 823				
Ontario	30 515	151 550			38 104
Manitoba					
Saskatchewan					
Alberta					
British Columbia	1 261				
Yukon, N.W.T.					
TOTAL CANADA	140 169	151 550			38 104

* Expressed as SO_2
** Expressed as NO_2

2.2 Pyrrhotite Roasting

2.2.1 Process Description. Pyrrhotite concentrate is treated to convert the contained iron into a form suitable for use in the steel industry, by eliminating most of its sulphur content and extracting and recovering the major portion of non-ferrous metals. Pyrrhotite concentrate is also roasted to produce sulphuric acid.

Only one plant was involved in the roasting of pyrrhotite for iron recovery in Canada in 1978 (8). The iron sulphide concentrate was oxidized to a low-sulphur calcine in the fluid bed roasters. The calcine was then processed through rotary kilns to reduce the non-ferrous metals selectively. These were in turn dissolved in an ammonia-ammonium carbonate solution. The solution was treated in a counter-current multi-stage leaching process for metal and reagent recovery and the leached iron oxide residue was pelletized and indurated. In the other plant, the pyrrhotite concentrate obtained by differential flotation was roasted for sulphuric acid production and the calcine was transferred to a tailings pond.

2.2.2 Emission Sources. The major emission sources from the pyrrhotite roasting process were the fluid-bed roasters and the reduction kilns. Particulates were also emitted during reagent recovery, pelletization and induration.

Particulate matter and sulphur oxides were the contaminants considered for these sources.

2.2.3 Controls. Particulate emissions from pyrrhotite roasting operations were generally well controlled. A sulphuric acid plant was used to control sulphur oxide emissions from the fluid-bed roasters. Before entering the acid plant, the gases were normally precleaned by cyclones and electrostatic precipitators. Cyclones and water scrubbers were used on the reduction kilns.

2.2.4 Emissions. The emissions were obtained from pertinent unpublished information (3, 7) and are presented in Table 5.

2.3 Iron and Steel Industry

2.3.1 Process Description. Iron is commonly extracted from its ore in a blast furnace to which iron ore, coke, and limestone are fed and then reacted at high temperatures under a high-velocity stream of hot air. Molten iron is removed from the furnace and is either directly transported to a steel mill or cast into pigs. The flue dust and other iron ore fines from the process are converted into useful blast furnace charge via sintering operations. A special grade of pig iron called silvery pig iron, produced in an

TABLE 5 TOTAL EMISSIONS, PYRRHOTITE ROASTING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec					
Ontario	2 369	26 171			
Manitoba					
Saskatchewan					
Alberta					
British Columbia	250	5 390			
Yukon, N.W.T.					
TOTAL CANADA	2 619	31 561			

* Expressed as SO_2
** Expressed as NO_2

electric smelting furnace, was produced at one plant. Another plant produced metallized pellets for application in further steelmaking operations by direct reduction techniques. In steel production, pig iron and/or steel scrap are charged to either a basic oxygen, open hearth or electric arc furnace. Pellets can also be charged depending on the availability of scrap. All of the steelmaking processes produce molten steel.

After the molten steel has attained the desired chemical composition, it is tapped from the furnace into a ladle. Several plants pour the liquid steel into the top of open-bottomed moulds in continuous casting machines where it solidifies and is continuously withdrawn from the bottom of the moulds in long lengths of the desired shapes. Other ancillary operations include scarfing (removal of surface defects of the shaped steel, which must be further processed), cold and hot rolling and annealing (removal of self-contained stresses of steel products).

2.3.2 Emission Sources. Contaminants considered were particulate matter, sulphur oxides and carbon monoxide. The major contributors of particulate emissions are the various furnace operations. Sulphur oxide emissions result from the open hearth furnace and sintering operations, whereas carbon monoxide results from sintering operations, electric arc furnaces, and annealing operations.

2.3.3 Controls. Particulates discharged from pig iron and steelmaking furnace operations were controlled to various levels of efficiency. Venturi scrubbers and electrostatic precipitators were the most common control devices on blast furnaces (up to 99% efficiency); baghouses were used for electric arc furnaces; and basic oxygen furnaces were controlled by precipitators or venturi scrubbers. Various ancillary operations at some plants also had control devices. Sulphur oxides and carbon monoxide were assumed to be largely uncontrolled.

2.3.4 Emissions. Emissions from both primary and non-integrated steel plants were calculated based on production data obtained from various unpublished sources (3, 6, 24). Site-specific process emission factors were developed using 1976 emission data (1, 3), hence no attempt has been made to list them. The extent and efficiency of controls was assumed to have remained at 1976 levels based on various consultations (6, 24, 25).

Total emissions for iron and steel production are listed in Table 6.

2.4 Primary Aluminum Production

2.4.1 Process Description. The production of aluminum is a two-step process. First, bauxite ore is ground, purified and calcined to produce alumina; then the alumina is electrically smelted.

The major portion of the aluminum produced in Canada in 1978 was processed in either horizontal- or vertical-stud Soderberg reduction cells. Prebake-type cells are now used only to a limited extent.

2.4.2 Emission Sources. The major sources of emissions were the aluminum reduction cells, although a large amount of particulates can be generated during the calcining of aluminum hydroxide. Particulates were also emitted from bauxite grinding and materials handling. In addition, emissions of particulates, nitrogen oxides and sulphur oxides arose from the manufacture of carbon electrodes at three of the aluminum smelters.

2.4.3 Controls. Only one plant in Canada refined alumina in 1978. As the calcining operation relied on a high recovery of the emitted dust, the control equipment installed (multicyclones and baghouses) provided an overall particulate removal efficiency of aproximately 95%. The bauxite grinding operation was controlled with a baghouse.

The electrolytic cells were normally covered and the exhaust fumes scrubbed before being discharged to the atmosphere. All the plants except one had scrubbers

TABLE 6 TOTAL EMISSIONS, IRON AND STEEL INDUSTRY, 1978

Source	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia	23 555	605			
New Brunswick					
Quebec	16 230	8 667			215 368
Ontario	32 371	1 817			31 700
Manitoba	432				1 017
Saskatchewan	2 053				3 431
Alberta	573				1 969
British Columbia	568				1 271
Yukon, N.W.T.					
TOTAL CANADA	75 782	11 089			254 756

* Expressed as SO_2

** Expressed as NO_2

(either wet or dry) on the cell-hood stacks. Emissions not captured by the cell hoods were untreated and discharged through the roof ventilators.

Coke dust emissions from the making of carbon electrodes were controlled by multicyclones or scrubbers.

2.4.4 **Emissions.** Particulate emissions from alumina refining operations were calculated from internal data (3). Aluminum production was obtained from published data (9) while the quantity of coke calcined was estimated based on internal information (3, 6, 10). Emission factors were taken from a previous publication (1).

Emission factors and total emissions from primary aluminum production are presented in Tables 7 and 8 respectively.

2.5 Primary Copper and Nickel Production

2.5.1 **Process Description.** The first step in the production of copper and nickel involves the concentration of low-grade sulphide ores by magnetic separation and/or flotation methods. The primary metals are then recovered from the concentrate either in the conventional manner involving four steps: roasting, smelting, converting and fire-refining, or by using some of the newly developed pyrometallurgical techniques.

TABLE 7 CONTROLLED EMISSION FACTORS, PRIMARY ALUMINUM PRODUCTION

Process	Emission factors (kg/tonne of product)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
ALUMINUM SMELTING					
Overall emission factors	b	b	-	1.3	139.45
MAKING OF CARBON ELECTRODES					
Coke Calcining[a]	2.6	19.9	21.5	-	-

* Expressed as SO_2
** Expressed as NO_2
a Emission factor expressed as kg/tonne coke processed
b Emissions obtained from actual plant data

TABLE 8 TOTAL EMISSIONS, PRIMARY ALUMINUM PRODUCTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec	47 785	45 953	6 253	1 016	108 991
Ontario					
Manitoba					
Saskatchewan					
Alberta					
British Columbia	9 409	6 133	2 150	432	37 700
Yukon, N.W.T.					
TOTAL CANADA	57 194	52 086	8 403	1 448	146 691

* Expressed as SO_2
** Expressed as NO_2

In the roasting of concentrates, about half the sulphur is driven off as sulphur dioxide and some of the iron is oxidized. The resulting material, known as calcine, is fed into a smelting furnace along with a siliceous flux and melted to form an iron silicate slag, and a solution of molten sulphides (matte). In converting, air is blown through the matte and additional sulphur is driven off the sulphide melt, and the remaining iron is oxidized. The matte is reduced to the crude metals which are further refined.

The pyrometallurgical process described above was the most common method used in Canada in 1978. One plant also produced primary nickel by a hydrometallurgical process.

2.5.2 Emission Sources. The major sources of emissions were the roasters, smelting furnaces and converters. Minor emissions may also be released from ore handling and refining operations. The hydrometallurgical process is relatively free of emissions. The contaminants considered for these sources were particulate matter and sulphur oxides.

2.5.3 Controls. Most of the plants used electrostatic precipitators to control particulate emissions from the gases from the roaster, smelting furnace and converter off-gases. In one case a baghouse was used for further cleaning of the combined reverberatory furnace and converter gas streams. Balloon flues, which serve as gravity collectors, and high-efficiency cyclones were also used as primary controls at some installations.

One copper smelter operated an acid plant to recover SO_2 from combined fluid bed roaster and converter off-gas streams. Another plant recovered liquid SO_2 from a flash smelting furnace off-gas stream.

2.5.4 Emissions. For some plants, emissions were obtained from unpublished information as well as from questionnaire data and literature (6, 3, 10). In other cases, production data obtained from the literature (11, 12) was used together with emission factors developed from earlier emission data (1). Because of the differences in processes from one plant to the other, emission factors could not be compared. Total emissions from primary copper and nickel production are listed in Table 9.

2.6 Copper and Nickel Refining

2.6.1 Process Description. The product at nickel and copper smelters is fire-refined metal at a purity of about 99.5 percent. For most applications, further purification of the metals is required; the fire-refined metals are cast into 'anodes' and shipped to refineries for electrolytic refining. Impurities are separated from the metals by electrolysis in large

TABLE 9 TOTAL EMISSIONS, PRIMARY COPPER AND NICKEL PRODUCTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec	19 060	575 360			
Ontario	13 697	657 858			
Manitoba	16 441	471 765			
Saskatchewan					
Alberta					
British Columbia	37	2 441			
Yukon, N.W.T.					
TOTAL CANADA	49 235	1 707 424			

* Expressed as SO_2
** Expressed as NO_2

tanks. The metallic impurities form a sludge which is treated for precious metal recovery, generally using pyrometallurgical processes. In the electrolysis, the nickel or copper is transferred onto the cathode which is remelted and made into marketable shapes.

2.6.2 Emission Sources. The major sources of emissions are the anode and remelting furnaces. Anode furnaces are used at refineries for remelting defective anodes and other scrap material. Process emissions consist of particulates and sulphur oxides. The electrolysis process is relatively free of emissions.

2.6.3 Controls. Electrostatic precipitators are used primarily to control the particulate emissions from furnaces. Baghouses are commonly used in other areas for controlling particulate emissions.

2.6.4 Emissions. Production data for copper refineries were taken from the literature (11); for nickel refineries, the nickel output from smelters (12) was assumed to be equivalent to the quantity of nickel refined. Emissions were determined from emission factors previously established (1) which were based on questionnaire data (3).

Total emissions from copper and nickel refining are listed in Table 10.

TABLE 10 TOTAL EMISSIONS, COPPER AND NICKEL REFINING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec	45				
Ontario	1 987	833			
Manitoba	15				
Saskatchewan					
Alberta					
British Columbia					
Yukon, N.W.T.					
TOTAL CANADA	2 047	833			

* Expressed as SO_2

** Expressed as NO_2

2.7 Primary Lead and Zinc Production

2.7.1 Process Description. Primary lead and zinc production consists of the extraction of these metals from their ores.

Lead metal is produced by oxidizing the concentrate in a sinter plant where lead sulphides are converted to oxides of lead and sulphur dioxide. The oxidized solid material is reduced with coke in a blast furnace. The resulting molten lead bullion is further refined by either electrolysis or chemical precipitation.

All the primary zinc in Canada in 1978 was produced by the electrolytic process which involves the roasting of the concentrate to drive off the sulphur and obtain oxidized zinc. The reduction and recovery of zinc is achieved by leaching the calcine with sulphuric acid, followed by electrolysis where the zinc is plated onto cathodes. The zinc cathodes are then melted and cast into ingots.

2.7.2 Emission Sources. The main emission sources in the primary lead and zinc industry were sinter plants, blast furnaces, roasters and electrolytic cells. Minor quantities of particulates were generated by ore crushing and materials-handling operations as well as from zinc melting furnaces.

Contaminants considered for these sources were particulate matter and sulphur oxides.

2.7.3 Controls. All the primary zinc producers, except one, had acid plants to control emissions of sulphur oxides from the roasters. Before entering the acid plant, the gases were cleaned by waste heat boilers and cyclones, followed by electrostatic precipitators and scrubbers to remove particulates. Emissions from zinc melting furnaces were normally controlled by impingers or by cyclones and baghouses.

The Canadian lead producers used scrubbers or an acid plant to control the sintering operations, and baghouses to control the blast furnace exhaust gases.

2.7.4 Emissions. Production data were taken from the literature (13, 14) except for one concentrate roasting plant; this information was obtained internally (6). Controlled emission factors varied from one plant to another and were obtained internally (3) and from other pertinent sources (1, 6).

Total emissions for primary lead and zinc production are given in Table 11.

TABLE 11 TOTAL EMISSIONS, PRIMARY LEAD AND ZINC PRODUCTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick	1 099	15 580			
Quebec	2 435	12 732			
Ontario	608	1 530			
Manitoba[a]					
Saskatchewan					
Alberta					
British Columbia	4 376	21 648			
Yukon, N.W.T.					
TOTAL CANADA	8 518	51 490			

* Expressed as SO_2

** Expressed as NO_2

[a] Emissions from this province are included under primary copper and nickel sector

2.8 Ferroalloy Manufacture

2.8.1 Process Description. Various kinds and grades of ferroalloys are produced in Canada. The main products are ferrosilicon, ferromanganese, silicomanganese and ferrochromium. The major portion of the ferroalloys produced in Canada in 1978 was processed in open-top electric furnaces. An aluminothermic furnace was used at one plant for the production of special alloys such as ferromolybdenum, ferrovanadium and ferrocolumbium.

The typical electric furnace used in the manufacture of ferroalloys is the submerged-arc type. Raw ore, coke and slagging materials are charged to the furnace in appropriate quantities. The intense heat zone around the carbon electrodes enables carbon reduction of the metallic oxides. The various impurities are trapped in the slag and molten ferroalloy is tapped from the bottom of the furnace and cast.

2.8.2 Emission Sources. The electric-smelting-furnace production method is a major source of air pollution. Large quantities of carbon monoxide are generated as a result of the carbon reduction of metallic oxides. The escaping gas also carries a substantial amount of particulates of submicron size. Particulate matter is emitted from raw-materials handling, crushing, grinding and sizing operations.

2.8.3 Controls. There were no controls on most of the furnace operations. It was estimated that the aluminothermic process was controlled to about 70% efficiency. Ancillary operations were usually well controlled. Baghouses were used in most situations with some use of cyclones.

2.8.4 Emissions. Production data, obtained from the literature (15), were used along with internally developed emission factors and unpublished information (6, 10).

There were also some industries which produced ferrosilicon and ferrophosphorus as by-products of their main process. Usually, however, these by-products were transported to waste dumps along with slag. These operations have not been included here. Emissions from the production of calcium carbide have been excluded from this industrial sector as well since this material cannot be classified as a ferroalloy.

Emission factors and total emissions for ferroalloy manufacture are presented in Tables 12 and 13 respectively.

2.9 Abrasives Manufacture

2.9.1 Process Description. Two types of synthetic abrasives are manufactured in Canada: aluminum oxide and silicon carbide.

TABLE 12 UNCONTROLLED EMISSION FACTORS, FERROALLOY MANUFACTURE

Operation	Emission factors (kg/tonne of product)[a] Particulate matter	 Sulphur Oxides*	 Carbon monoxide[b]
Materials Handling	0.84		
Drying, Sintering & Smelting	100.7	7.2	63.9
Sizing & Packaging	0.18		

* Expressed as SO_2.

[a] Average emission factors for ferroalloy plants in the province of Quebec only. Only one plant was located in Ontario; emission factors are not given because of confidentiality.

[b] Emission factors based on the assumption that 10% of the CO produced in the furnace escapes to the atmosphere.

TABLE 13 TOTAL EMISSIONS, FERROALLOY MANUFACTURE, 1978

	Emissions (tonnes) Particulate matter	 Sulphur oxides*	 Nitrogen oxides**	 Hydro-carbons	 Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec	25 368	1 774			15 754
Ontario	1	8			
Manitoba					
Saskatchewan					
Alberta					
British Columbia					
Yukon, N.W.T.					
TOTAL CANADA	25 369	1 782			15 754

* Expressed as SO_2

** Expressed as NO_2

The production of aluminum oxide involves the smelting of bauxite ore in an electric furnace along with iron borings and coke. The by-product of this process is ferrosilicon.

The production of silicon carbide involves the smelting of silica sand with petroleum coke in an electric-resistance furnace. The final product is then cooled and crushed.

2.9.2 Emission Sources. Substantial amounts of dust and fumes are created during smelting operations. Particulate emissions also occur from the drying of petroleum coke and from product sizing.

Large amounts of particulate are released from both synthetic abrasives manufacturing processes. Unreacted carbon monoxide is evolved in the silicon carbide process, and, to a lesser degree, in the production of aluminum oxide. Part of the sulphur contained in the petroleum coke used in silicon carbide production is released as sulphur oxides. One company uses elemental sulphur to increase the purity of its aluminum oxide.

2.9.3 Controls. The melting operation in aluminum oxide production was controlled in a limited number of installations by baghouses; emissions from resistance furnaces in silicon carbide processing were uncontrolled. The level of control for the industry as a whole was assumed to be minimal.

2.9.4 Emissions. Canadian production was obtained from a Statistics Canada publication (16). Additional information on a provincial basis was taken from an Energy, Mines, and Resources publication (17). Emission factors for the industry were obtained from the Air Pollution Control Directorate (6) and had been revised since the publication of the 1976 inventory. Emissions from by-products have not been included as they are already considered in the overall plant emissions.

Emission factors and total emissions for abrasives manufacture are presented in Tables 14 and 15 respectively.

2.10 Ferrous Foundries

2.10.1 Process Description. Iron and steel castings are produced in one of four furnaces: cupola, reverberatory, electric induction or electric arc. The cupola was the furnace most widely encountered in Canada in 1978, although the other types were also used to a limited extent.

The furnace charge consists of metallics, flux materials and, in the case of cupola melting, coke for fuel. Molten metal is tapped into a temporary holding unit or into a ladle for pouring into moulds. When cooled, the mould is transferred to a shake-out area where the sand and castings are separated by manual or mechanical means.

TABLE 14 UNCONTROLLED EMISSION FACTORS, ABRASIVES MANUFACTURE

Process	Emission factors (kg/tonne of product)				
	Particulate Matter*		Sulphur oxides**		
	Fused Aluminum	Silicon Carbide	Fused Aluminum	Silicon Carbide	Carbon Monoxide
Abrasives manufacture					
Ontario	25	24	14.3	46.4	25.0
Quebec	70	25	2.5	65.8	25.0

* Controlled emission factors

** Expressed as SO_2

TABLE 15 TOTAL EMISSIONS, ABRASIVES MANUFACTURE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec	2 721	3 731			1 872
Ontario	4 810	4 142			4 852
Manitoba					
Saskatchewan					
Alberta					
British Columbia					
Yukon, N.W.T.					
TOTAL CANADA	7 531	7 873			6 724

* Expressed as SO_2

** Expressed as NO_2

2.10.2 Emission Sources. The major emission source is the cupola furnace, with the electric arc, induction and reverberatory furnaces emitting smaller amounts. Emissions consist of metallic oxides, fumes, dust and gases. A large amount of particulate matter is also generated by non-melting operations such as shake-out, shot-blasting and sand conditioning.

Contaminants considered for these sources were particulate matter and carbon monoxide.

2.10.3 Controls. A variety of air pollution control equipment was used in melting operations. Scrubbers and wet caps were commonly installed on cupolas, although cyclones and sometimes baghouses were also used. Collector units used on electric arc furnaces were baghouses and scrubbers. In addition to the dust collection equipment systems, a variety of hoods, ventilating and exhaust systems were employed to capture or exhaust foundry emissions. Particulate matter control on a provincial basis was estimated to vary between 10% and 65%. Carbon monoxide emissions were assumed to be controlled with afterburners on cupola furnaces.

2.10.4 Emissions. Production of iron at iron foundries was obtained from unpublished information (18) which included the output from General Motors. Steel production data was found to be incomplete and contradictory in various published sources. Output from steel foundries was therefore estimated using published information from a questionnaire survey of the industry (19) and from an Energy, Mines and Resources Canada publication (20).

Emission factors, available on a plant-by-plant basis, were obtained from unpublished material (6) and were averaged to obtain a national figure.

Emission factors and total emissions for ferrous foundries are presented in Tables 16 and 17 respectively.

2.11 Magnesium Production

2.11.1 Process Description. A silicothermic process (Pidgeon process) was used by the only plant that produced primary magnesium in Canada in 1978. The process consists of two steps:

(1) The high quality dolomite is calcined in a rotary kiln

(2) The resulting product "dolime" is mixed with ferrosilicon and charged into retorts for external heating under high vacuum and high temperature. The magnesium content is reduced and collected on the lining of a condenser, and the condensate is then remelted and cast into ingots of magnesium.

2.11.2 Emission Sources. Particulates are the only contaminants considered and result from calcining and drying of the dolomite.

2.11.3 Controls. A control efficiency of 90% was attained using multiclones (3).

TABLE 16 AVERAGE CONTROLLED EMISSION FACTORS, FERROUS FOUNDRIES

Type of Furnace	Emission factors* (kg/tonne of melt) Particulate matter	Carbon monoxide
Cupola	2.85	4.5
Reverberatory	1.0**	
Induction	0.75**	
Electric Arc	2.10	
Non-Melting Operations	2.66	

* These factors have been determined from individual plant data and have been averaged by dividing the total emissions by the total of hot metal produced.

** Uncontrolled emission factor.

TABLE 17 TOTAL EMISSIONS, FERROUS FOUNDRIES, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	4				1
Prince Edward Island	10				2
Nova Scotia	162				28
New Brunswick	486				128
Quebec	3 975				988
Ontario	4 674				5 011
Manitoba	1 508				85
Saskatchewan	29				5
Alberta	680				281
British Columbia	534				186
Yukon, N.W.T.					
TOTAL CANADA	12 062				6 715

* Expressed as SO_2

** Expressed as NO_2

2.11.4 **Emissions.** A controlled emission factor of 2.2 kg/tonne has been assumed for the drying operation (23), with production data available from a questionnaire (3). Calcining emissions were also obtained from questionnaire data (3).

Emissions from magnesium production are listed in Table 18.

TABLE 18 TOTAL EMISSIONS, MAGNESIUM PRODUCTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec					
Ontario	329				
Manitoba					
Saskatchewan					
Alberta					
British Columbia					
Yukon, N.W.T.					
TOTAL CANADA	329				

* Expressed as SO_2
** Expressed as NO_2

2.12 Asbestos Production

2.12.1 Process Description. The production of asbestos involves two major operations: mining and milling.

Mining consists of extracting the fibre-bearing ore from the ground and transporting it to the mill. The milling operation involves the separation of the asbestos fibre (e.g., chrysotile) from coexisting rock by coarse crushing, drying and recrushing in stages. Each step is followed by screening and air suction, to free the fibres from rock and dust. The asbestos fibres are cleaned, graded and bagged for shipment and the waste is conveyed to tailings dumps.

2.12.2 Emission Sources. Each of the processes associated with asbestos mining and milling is a potential emission source. Significant sources of particulate matter are tailings disposal and mining operations. Minor quantities of particulates are generated by crushing and drying of asbestos ore, as well as milling and shipping operations.

Particulate emissions considered for these sources included both rock dust and asbestos fibre.

2.12.3 Controls. Most of the asbestos milling facilities had emission control equipment. Cyclones and baghouses operating at estimated control efficiencies of 70% and 99.8% respectively were commonly used.

2.12.4 Emissions. Particulate emissions from the Canadian asbestos industry were calculated using production data (21) and emission factors developed from an Environment Canada report (22). These emission factors considered particulate emission reduction for various processes, relative to the information supplied in the 1977 published study of the industry (22).

Emission factors and total emissions for asbestos production are listed in Tables 19 and 20 respectively.

TABLE 19 CONTROLLED EMISSION FACTORS, ASBESTOS PRODUCTION

	Emission factors (kg/tonne of ore mined)	
	Particulate Matter	
Process	Quebec	Rest of Canada
Crushing	0.03	0.05
Drying	0.12	0.13
Dry-rock storage	0.03	0.04
Milling	0.83	0.89
Tailings	49.55	80.64

2.13 Mining and Rock Quarrying

2.13.1 Process Description. The metal mining and stone quarrying industries handle large volumes of a variety of materials, mostly rock, using various techniques.

Mining operations are carried out underground or in an open pit while stone quarrying is always an open-pit operation. Regardless of the operation, the methods used for rock removal are similar. The rock is drilled, blasted, loaded and transported to a crushing site via trucks or conveyors. In open-pit mining, overburden material has to be removed to expose the rock.

TABLE 20 TOTAL EMISSIONS, ASBESTOS PRODUCTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	3 013				
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec	63 879				
Ontario					
Manitoba					
Saskatchewan					
Alberta					
British Columbia	5 580				
Yukon, N.W.T.	4 353				
TOTAL CANADA	76 825				

* Expressed as SO_2
** Expressed as NO_2

2.13.2 Emission Sources. Drilling, blasting, loading and transporting create dust emissions. In underground mining, the emissions are naturally lower than from open-pit mines. However, particulates are nonetheless emitted through the ventilation systems.

Blasting agents also generate nitrogen oxides and some hydrocarbons, but do not contribute significantly to the pollution burden and are not considered in this inventory.

Emissions from iron ore, coal and salt mining were dealt with in their respective sectors.

2.13.3 Controls. Dust emissions are controlled to some extent by water spraying when operating conditions are dry.

2.13.4 Emissions. Mine and quarry productions were obtained from the literature (26, 27, 28). The quantities produced by underground or open-pit mining methods were approximated using published mill capacities data (29). Emission factors for mining operations were taken from a U.S. Environmental Protection Agency publication (30). A particulate emission factor of 0.05 kg/tonne was used for underground mining, whereas 0.51 kg/tonne was used for open-pit mining. Gaseous emissions from blasting were assumed to be negligible (6).

Total emissions for mining and rock quarrying are summarized in Table 21.

TABLE 21 TOTAL EMISSIONS, MINING AND ROCK QUARRYING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	10 423				
Prince Edward Island					
Nova Scotia	4 072				
New Brunswick	8 033				
Quebec	60 002				
Ontario	33 550				
Manitoba	3 837				
Saskatchewan	2 310				
Alberta	790				
British Columbia	66 652				
Yukon	1 607				
N.W.T.	1 533				
TOTAL CANADA	192 809				

* Expressed as SO_2

** Expressed as NO_2

2.14 Salt Production

2.14.1 Process Description. In Canada, three different methods of salt production are employed. About 70 percent of the total salt output is mined. The salt rock is removed from the earth, crushed, screened and packaged.

Fine vacuum salt and recovery of salt from brine are the other two methods of production. In each case, the salt is passed through dryers and subsequently crushed and screened.

2.14.2 Emission Sources. Crushing, screening, and handling operations all generate particulate emissions. The dryers used in the production of fine vacuum salt and salt from brine also generate particulate emissions.

2.14.3 Controls. Particulate emissions are controlled by fabric filters.

2.14.4 Emissions. The production of salt was obtained from published literature (31). The emission factor for mined salt was assumed to be similar to that reported for "Stone Quarrying and Processing" by the U.S. Environmental Protection Agency (4).

The emission factor for the other methods of salt production was assumed to be 2.19 kg/t, which was developed internally and is equivalent to that used in the potash industry (32).

Emission factors and total emissions from salt production are summarized in Tables 22 and 23 respectively.

TABLE 22 CONTROLLED EMISSION FACTORS, SALT PRODUCTION

Process	Emission factors (kg/tonne of salt production)
	Particulate Matter
Rock salt	
Primary crushing	0.05
Secondary crushing and screening	0.30
Screening, conveying and handling	1.0
TOTAL	1.35
Brine and vacuum salt	2.190

TABLE 23 TOTAL EMISSIONS, SALT PRODUCTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia	1 452				
New Brunswick					
Quebec					
Ontario	7 219				
Manitoba	66				
Saskatchewan	681				
Alberta	725				
British Columbia					
Yukon, N.W.T.					
TOTAL CANADA	10 143				

* Expressed as SO_2
** Expressed as NO_2

2.15 Lime Manufacture

2.15.1 Process Description. The production of lime involves the crushing and handling of carbonate rocks more commonly known as limestone. The burning of lime consists essentially of the calcination of limestone at a sufficiently high temperature to decompose the calcium carbonate and drive off the gaseous carbon dioxide. Calcination is accomplished in kilns of various types but mainly those of vertical and rotary design are used in Canada.

2.15.2 Emission Sources. The major sources of emissions were the crushing, handling and lime kiln operations. Particulate matter was the only contaminant considered for these sources.

2.15.3 Controls. The degree of control for each province was estimated by the Air Pollution Control Directorate. It was assumed that emissions from crushing operations were controlled at efficiencies varying from 50% to 85%, whereas those from rotary kilns were controlled from 70% to 90%. Emissions from vertical kilns were considered to be uncontrolled.

2.15.4 Emissions. To calculate emissions, Canadian lime production statistics and U.S. Environmental Protection Agency emissions factors were used (4, 33). This was supplemented by data on the type of kilns and capacities for each Canadian plant (18, 34).

Emission factors and total emissions for lime manufacture are listed in Tables 24 and 25 respectively.

2.16 Gypsum Processing

2.16.1 Process Description. The processing of gypsum, a naturally occurring hydrated calcium sulphate mineral, involves the drying, grinding and handling of aggregates in preparation for calcining.

Calcination of finely ground gypsum takes place in a large heated calciner, where gypsum loses its water of hydration and becomes plaster of paris.

2.16.2 Emission Sources. The major source of emission was the calciner. Other sources were operations involved in the grinding and drying of raw materials.

Particulate matter was the only contaminant considered for these sources.

2.16.3 Controls. Specific information on the control equipment actually installed in 1978 was not available. Therefore, an overall control efficiency of 90% was assumed. Baghouses and electrostatic precipitators are the most widely used control equipment.

TABLE 24 UNCONTROLLED EMISSION FACTORS, LIME MANUFACTURE

	Emission factors (kg/tonne of lime)
Process	Particulate Matter
CRUSHING	
Primary	15.5
Secondary	1.0
CALCINING	
Vertical kiln	4.0
Rotary kiln	100.0
Vibratory kiln	100.0
Calcimatic kiln	100.0
Fugitive Emissions	1.6

TABLE 25 TOTAL EMISSIONS, LIME MANUFACTURE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick	989				
Quebec	6 875				
Ontario	15 071				
Manitoba	2 313				
Saskatchewan					
Alberta	2 424				
British Columbia	1 378				
Yukon, N.W.T.					
TOTAL CANADA	29 050				

* Expressed as SO_2

** Expressed as NO_2

2.16.4 Emissions. Emissions of particulates by the gypsum processing industry were calculated using U.S. Environmental Protection Agency emission factors (4) and related information on production data (35). It was assumed that processing of the gypsum was not done at the mine site, as was done in previous calculations (1).

Emission factors and total emissions for gypsum processing are presented in Tables 26 and 27 respectively.

TABLE 26 UNCONTROLLED EMISSION FACTORS, GYPSUM PROCESSING

Process	Emission factors (kg/tonne of throughput) Particulate Matter
Raw materials drying	20.0
Primary grinding	0.5
Calcining	45.0
Conveying	0.35
Total	65.85

TABLE 27 TOTAL EMISSIONS, GYPSUM PROCESSING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	575				
Prince Edward Island					
Nova Scotia	316				
New Brunswick	392				
Quebec	4 319				
Ontario	6 536				
Manitoba	1 295				
Saskatchewan	777				
Alberta	2 331				
British Columbia	2 995				
Yukon, N.W.T.					
TOTAL CANADA	19 536				

* Expressed as SO_2
** Expressed as NO_2

2.17 Nepheline Syenite Processing

2.17.1 Process Description. Nepheline syenite processing involves the crushing and blending of quarry material from various parts of the pit to ensure an acceptable mill feed.

Ontario was the only Canadian province involved in nepheline syenite processing in 1978. Two mills were in operation processing rock from three quarries.

2.17.2 Emission Sources. Dust emissions originate from crushing and screening, milling, handling, and from storage piles.

2.17.3 Controls. An industry-average control efficiency of 95% was assumed on all sources except conveying and handling operations, which were assumed to be uncontrolled.

2.17.4 Emissions. Data on the production of nepheline syenite were obtained from the literature (36, 37). Emission factors were obtained from a U.S. Environmental Protection Agency publication (4). Storage pile losses were estimated using a form of the Thornthwaite Moisture Index (3).

Emission factors and total emissions for nepheline syenite processing are presented in Tables 28 and 29 respectively.

2.18 Fluorspar Processing

2.18.1 This process involves the primary and secondary crushing, screening and handling of fluorspar aggregates.

The only Canadian mine was located in Newfoundland and was still operating in 1976 but ceased operation in late 1977. The emissions from this industrial sector were therefore negligible in 1978.

2.19 Potash Processing

2.19.1 Process Description. The main source of potash is the mineral sylvite, which is usually found in association with halite (NaCl) and is mined either by underground excavation or by solution extraction. Broken rock or potash-rich solutions are transferred to the surface plant where further refining, by flotation or evaporation and crystallization, takes place. Rock mined by conventional excavation methods is crushed and the sylvite is removed by flotation. It is then dried and screened to provide different grades of potassium chloride. Evaporation and crystallization refining processes are mainly used for solution-mining methods. Only one plant in Canada used solution-mining methods in 1978.

TABLE 28 UNCONTROLLED EMISSION FACTORS, NEPHELINE SYENITE PROCESSING

Operation	Emission factors (kg/tonne) Particulate Matter
CRUSHING OPERATIONS	
Primary crushing	0.25
Secondary crushing and screening	0.75
Recrushing and screening	2.5
Fines mills	3.0
MISCELLANEOUS OPERATIONS	
Screening, handling and conveying	1.0
Storage pile losses	0.14

TABLE 29 TOTAL EMISSIONS, NEPHELINE SYENITE PROCESSING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec					
Ontario	460				
Manitoba					
Saskatchewan					
Alberta					
British Columbia					
Yukon, N.W.T.					
TOTAL CANADA	460				

* Expressed as SO_2
** Expressed as NO_2

2.19.2 Emission Sources. Potash is mined underground; however, this section covers only above-ground processing. This includes crusher and grinder, product dryer, product sizing and handling and product storage and loading. Finely divided salt particulates produced in the refining process, particularly during drying and screening operations, are the major problem.

Particulate matter was the only contaminant considered for this industry.

2.19.3 Controls. Wet scrubbers and cyclones were the most common control devices used for the product dryers and crushing and grinding operations. Mechanical collectors, scrubbers and baghouses were used in other plant operations.

2.19.4 Emissions. Particulate emissions were calculated based on source sampling data for the year 1979 (78) and U.S. Environmental Protection Agency emission factors (4). Production data was obtained from the Department of Energy, Mines and Resources (57, 58).

Total emissions attributable to the potash processing industry are given in Table 30.

TABLE 30 TOTAL EMISSIONS, POTASH PROCESSING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec					
Ontario					
Manitoba					
Saskatchewan	22 802				
Alberta					
British Columbia					
Yukon, N.W.T.					
TOTAL CANADA	22 802				

* Expressed as SO_2
** Expressed as NO_2

2.20 Silica Processing

2.20.1 Process Description. Silica processing involves the primary and secondary crushing, screening, milling and handling of aggregates.

2.20.2 Emission Sources. Dust emissions originate mainly from the crushing and screening operations, from milling and from storage piles.

2.20.3 Controls. Control efficiencies of 95% were assumed for the crushing and screening operations, and 70% for conveying and handling since dust pick-up points do not cover the whole operation. Baghouses are the control equipment utilized.

2.20.4 Emissions. Particulate emissions were estimated using U.S. Environmental Protection Agency emission factors for stone processing as well as published production data (4, 86). Since some provincial production data were not available, values were obtained by proration based on dollar values. Storage pile losses were estimated using a form of the Thornthwaite Moisture Index (3).

Emission factors and total emissions for the silica processing industry are presented in Tables 31 and 32 respectively.

TABLE 31 UNCONTROLLED EMISSION FACTORS, SILICA PROCESSING

	Emission factors (kg/tonne of throughput)
Process	Particulate Matter
CRUSHING OPERATIONS	
Primary crushing	0.25
Secondary crushing and screening	0.75
Recrushing and screening	2.5
Fines mills	3.0
MISCELLANEOUS OPERATIONS	
Screening, conveying and handling	1.0
Storage pile losses	0.19

2.21 Stone Processing

2.21.1 Process Description. This process involves the primary and secondary crushing, screening, milling and handling of stone aggregates.

TABLE 32 TOTAL EMISSIONS, SILICA PROCESSING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	13				
Prince Edward Island					
Nova Scotia	18				
New Brunswick					
Quebec	271				
Ontario	406				
Manitoba	189				
Saskatchewan	62				
Alberta	99				
British Columbia	11				
Yukon, N.W.T.					
TOTAL CANADA	1 069				

* Expressed as SO_2
** Expressed as NO_2

Stone can be produced in a large variety of sizes such as building stone, pulverized stone, crushed stone, and rubble and riprap. Crushed stone accounted for about 85% of total stone production in Canada in 1978.

2.21.2 Emission Sources. Dust emissions occurred from all the above unit operations, as well as from storage piles, and from conveying and drying operations.

2.21.3 Controls. A control efficiency of 95% was attained by using baghouses, except for material handling and storage pile losses. An efficiency of 70% was assumed for the handling operation.

2.21.4 Emissions. Total shipments of stone by province were obtained from Energy, Mines and Resources Canada (49). Breakdown by type of stone was estimated using information provided by Statistics Canada (48). An emission factor for the production of building stone was estimated by the Air Pollution Control Directorate. All other emission factors were based on U.S. Environmental Protection Agency publications (4, 50). Storage pile losses were computed using a form of the Thornthwaite Moisture Index (3).

Emission factors and total emissions for stone processing are listed in Tables 33 and 34 respectively.

TABLE 33 UNCONTROLLED EMISSION FACTORS, STONE PROCESSING

Process	Emission factors (kg/tonne of throughput) Particulate Matter
BUILDING STONE	
Cutting, etc.	1.0
PULVERIZED STONE	
Primary crushing	0.28
Secondary crushing and screening	0.07
Fugitive secondary crushing	0.24
Recrushing and screening	2.5
Fines mills	3.0
Screening, conveying and handling	1.0
Storage pile losses	0.16
CRUSHED STONE	
Primary crushing	0.25
Secondary crushing	0.12
Fugitive secondary crushing	0.24
Screening, conveying and handling	1.0

2.22 Sand and Gravel Processing

2.22.1 Process Description. Sand and gravel deposits are quarried, transported to the plant and then washed, crushed, screened and stockpiled.

2.22.2 Emission Sources. The major sources of particulate emissions were the screening and crushing operations.

2.22.3 Controls. Control measures normally consisted of wetting the material to minimize dusting during handling operations. It was assumed that no control equipment was used for particulate emissions from the crushing and screening operations.

2.22.4 Emissions. Emissions were calculated using an uncontrolled particulate emission factor of 0.05 kg/tonne (5) and pertinent data on shipments of sand and gravel (51).

TABLE 34 TOTAL EMISSIONS, STONE PROCESSING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	166				
Prince Edward Island					
Nova Scotia	752				
New Brunswick	1 604				
Quebec	18 518				
Ontario	13 003				
Manitoba	692				
Saskatchewan					
Alberta	229				
British Columbia	1 240				
Yukon, N.W.T.					
TOTAL CANADA	36 203				

* Expressed as SO_2
** Expressed as NO_2

Estimated total particulate emissions attributable to sand and gravel processing are presented in Table 35.

TABLE 35 TOTAL EMISSIONS, SAND AND GRAVEL PROCESSING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	231				
Prince Edward Island	44				
Nova Scotia	453				
New Brunswick	272				
Quebec	3 589				
Ontario	3 992				
Manitoba	748				
Saskatchewan	463				
Alberta	1 216				
British Columbia	2 291				
Yukon, N.W.T.					
TOTAL CANADA	13 299				

* Expressed as SO_2
** Expressed as NO_2

2.23 Cement Manufacture

2.23.1 Process Description. Cement is produced by quarrying and crushing limestone, and shale or clay. The raw materials are proportioned, ground and blended using either the wet or dry process. Slurry and dry raw materials are burned in a kiln to form clinker, which is then blended with a small amount of gypsum, ground into fine powder, and stored.

2.23.2 Emission Sources. The main pollution problem associated with cement manufacturing is the emission of particulates resulting from the following operations.

- Quarrying and crushing
- Preparation of raw materials
- Kiln operations
- Clinker cooling
- Finish grinding
- Packaging

Of the above sources, emissions from kiln operations represent the largest portion.

2.23.3 Controls. All the cement plants in Canada had some type of emission control system operating at various degrees of efficiency. The most common were electrostatic precipitators on kiln exhaust gases and high efficiency baghouses on finish grinding operations.

2.23.4 Emissions. To calculate emissions, Canadian cement production statistics and controlled particulate emission factors (developed from industrial questionnaire data) were used (85, 6).

Estimated total particulate emissions attributable to cement manufacture are presented in Table 36.

2.24 Concrete Batching

2.24.1 Process Description. Sand, gravel and cement are proportioned by means of weigh hoppers and conveyors and discharged with water into a mixing receiver such as a transit-mix truck. The batch product is then transported to the construction site for building purposes.

2.24.2 Emission Sources. Particulates are released during the concrete batching operations such as material handling, loading, conveying, mixing and unloading. Movement of trucks over dusty surfaces at the site is another source of dust emissions.

TABLE 36 TOTAL EMISSIONS, CEMENT MANUFACTURE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	663				
Prince Edward Island					
Nova Scotia	199				
New Brunswick	302				
Quebec	35 618				
Ontario	1 865				
Manitoba	2 487				
Saskatchewan	1 497				
Alberta	4 085				
British Columbia	1 045				
Yukon, N.W.T.					
TOTAL CANADA	47 761				

* Expressed as SO_2
** Expressed as NO_2

2.24.3 Controls. A control efficiency of 60% was used for the province of Saskatchewan (78). For the remainder of Canada, an overall control efficiency of 75% was assumed.

2.24.4 Emissions. Production figures for concrete batching plants were obtained from the literature (79, 30). An emission factor was based on a U.S. Environmental Protection Agency publication (4).

Emission factors and total emissions from concrete batching are listed in Tables 37 and 38 respectively.

TABLE 37 UNCONTROLLED EMISSION FACTORS, CONCRETE BATCHING

	Emission factors (kg/m^3)
Source	Particulate Matter
Concrete batching	0.12

TABLE 38 TOTAL EMISSIONS, CONCRETE BATCHING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	26				
Prince Edward Island	26				
Nova Scotia	45				
New Brunswick	45				
Quebec	494				
Ontario	853				
Manitoba	62				
Saskatchewan	110				
Alberta	342				
British Columbia	204				
Yukon, N.W.T.					
TOTAL CANADA	2 207				

* Expressed as SO_2
** Expressed as NO_2

2.25 Asphalt Production

2.25.1 Process Description. The first step in the production of hot-mix asphalt is the conveying of proportioned quantities of cold aggregates, such as sand, slag or fragments of stone and gravel, to a dryer. Dry aggregates are then screened, classified and mixed with hot asphalt. The final mixing process can be either of the batch or continuous type.

2.25.2 Emission Sources. The asphalt rotary dryer is the major source of emissions. Uncontrolled emissions from this source amount to approximately 5% of the total weight throughput. Other sources of particulate emissions include hot aggregate elevators, screens, storage bins, weigh hoppers, mixers, and transfer points.

2.25.3 Controls. Most of the asphalt plants in Canada had some type of air pollution control equipment, mainly wet scrubbers and baghouses, with some multicyclones. The degree of control was estimated to vary between 70% and 99%.

2.25.4 Emissions. Production of asphalt mix was calculated using asphalt consumption figures and asphalt sales figures obtained from Statistics Canada publications (43, 44). Emissions were calculated using Air Pollution Control Directorate emission factors (45). For Alberta, the emission factor was developed through source testing by Alberta

Environment (46). Asphalt mix was assumed to contain 7% asphalt and 93% aggregate by weight (47). Asphalt weighed 1.047 kg per litre (42).

Estimated total particulate emissions attributable to asphalt production are presented in Table 39.

TABLE 39 TOTAL EMISSIONS, ASPHALT PRODUCTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	1 144				
Prince Edward Island	1 630				
Nova Scotia	3 468				
New Brunswick	4 361				
Quebec	20 079				
Ontario	14 298				
Manitoba	3 963				
Saskatchewan	4 932				
Alberta	3 217				
British Columbia	7 157				
Yukon, N.W.T.	9				
TOTAL CANADA	64 258				

* Expressed as SO_2

** Expressed as NO_2

2.26 Glass Manufacturing

2.26.1 Process Description. Most of the glass produced in Canada is the soda-lime type. Its major ingredients are sand, limestone, soda ash, and cullet. The mixture of these materials is melted at high temperature (1500°C) in large, direct-fired, continuous, regenerative furnaces. After a little cooling, the product is delivered to the glass-forming machines, and then conveyed to annealing ovens for heat treatment. Three major products are made in Canada: flat glass, glass containers, and pressed and blown glass, containers accounting for about 90% of the total.

2.26.2 Emission Sources. The most significant source of particulate emissions in glass production is the regenerating furnace during the melting process. Handling, mixing and storage of raw materials, glass-forming machines and annealing ovens are minor sources of emissions of air contaminants.

2.26.3 **Controls.** The regenerative furnaces were generally equipped with wet centrifugal scrubbers or baghouses to control the particulates.

2.26.4 **Emissions.** Production figures for glass manufacturing plants in Canada were calculated from pertinent information (69, 73, 77). Emission factors for each product formed were obtained from various U.S. Environmental Protection Agency publications (74, 75, 76). Plants were assumed to operate an average of 350 days per year.

Emission factors and total emissions from glass manufacturing are listed in Tables 40 and 41 respectively.

TABLE 40 CONTROLLED EMISSION FACTORS, GLASS MANUFACTURING

	Emission factors (kg/tonne of product)
Source	Particulate Matter
Flat glass	1.0
Glass containers	0.68
Pressed and blown glass	8.7

TABLE 41 TOTAL EMISSIONS, GLASS MANUFACTURING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick	33				
Quebec	329				
Ontario	838				
Manitoba					
Saskatchewan					
Alberta	70				
British Columbia	140				
Yukon, N.W.T.					
TOTAL CANADA	1 410				

* Expressed as SO_2

** Expressed as NO_2

2.27 Clay Products Manufacture

2.27.1 Process Description. The manufacture of clay products involves the mining, grinding and blending of raw materials, and the forming, cutting, drying and firing of the final product. In Canada, gas, oil and coal are normally used for kiln heating.

This sector includes emissions from the manufacturing of bricks, structural and drain tiles, clay sewer pipes, flue lining, glazed floor and wall tiles, and firebrick.

2.27.2 Emission Sources. The major source of dust is the materials-handling operation which includes the drying, grinding, and storing of raw materials. The other contaminants are combustion products emitted mainly from the fuel consumed in kiln-firing operations.

2.27.3 Controls. Grinding and drying operations were assumed to be controlled at 96% efficiency, whereas kiln-firing operations were considered to be uncontrolled. Storage facilities for raw materials were enclosed. An overall control efficiency of 90% was assumed for the grinding and storage enclosure operations.

2.27.4 Emissions. The quantity of clay products manufactured in Canada was obtained from several publications (66, 67, 68). A listing of plants manufacturing various clay products, their capacity, and the type of fuel used was found in pertinent literature (69). Emission factors were based on data from the U.S. Environmental Protection Agency (4). Sulphur and ash content of fuels (included in the emission factors) were obtained from an internal government source (70). Emissions from kiln firing are included in Section 3.2 under Industrial Fuel Combustion.

Emission factors and total emissions for clay products manufacture are presented in Tables 42 and 43 respectively.

2.28 Crude Oil Production

2.28.1 Process Description. Crude oil is obtained from underground wells. The crude is lifted from the well by rod or submersible pump and is subsequently piped to a refinery.

Crude oil is also imported into Canada from other oil producing countries and is delivered by ocean-going vessels.

2.28.2 Emission Sources. Contaminants emitted into the ambient air are fugitive leaks. The most prevalent leaks are associated with pumps and valves; flanges and other types of connectors do not contribute significantly to the overall leak rate. Most crude

TABLE 42 UNCONTROLLED EMISSION FACTORS, CLAY PRODUCTS MANUFACTURE

	Emission factors (kg/tonne of product)
Source	Particulate matter
Dryer-Grinder	48.0
Storage	17.0

TABLE 43 TOTAL EMISSIONS, CLAY PRODUCTS MANUFACTURE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	70				
Prince Edward Island					
Nova Scotia	480				
New Brunswick	193				
Quebec	2 995				
Ontario	7 325				
Manitoba	42				
Saskatchewan	355				
Alberta	865				
British Columbia	397				
Yukon, N.W.T.					
TOTAL CANADA	12 722				

* Expressed as SO_2

** Expressed as NO_2

oil is transported by pipeline, resulting in negligible emissions, but hydrocarbons are evolved during the unloading of ships.

2.28.3 Controls. The fugitive emissions are released without control of flow or direction and consequently no direct control can be used. Quality and degree of maintenance is the significant factor in reducing most fugitive emission losses.

2.28.4 Emissions. Canadian crude oil production was obtained from the literature (135). Emission factors for fugitive emissions were taken from a U.S. Environmental Protection Agency publication (71).

The quantity of oil imported was estimated using refinery throughputs obtained from published literature (72). An emission factor of 0.275 kg/10^3 litres of oil unloaded was used in estimating transportation losses. Emission factors and total emissions for crude oil production are listed in Tables 44 and 45 respectively.

TABLE 44 EMISSION FACTORS, CRUDE OIL PRODUCTION

Source	Emission factors (kg/10^6 litres production) Hydrocarbons
Compressor seals	11.4
Relief valves	22.8
Waste water separators	22.8
Pipeline valves	34.2
Pumps	213.8
Total	305.0

TABLE 45 TOTAL EMISSIONS, CRUDE OIL PRODUCTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland				172	
Prince Edward Island					
Nova Scotia				2 312	
New Brunswick				2 030	
Quebec				1 234	
Ontario				29	
Manitoba				183	
Saskatchewan				2 945	
Alberta				19 837	
British Columbia				667	
Yukon, N.W.T.				45	
TOTAL CANADA				29 454	

* Expressed as SO_2

** Expressed as NO_2

2.29 Petroleum Refining

2.29.1 Process Description. Refining consists of the breaking down of crude oil into a number of consumer products and involves four major processes: separation, conversion, treating, and blending.

Distillation is employed to separate crude oil into various components of different boiling ranges. Each of these fractions may then be subjected to further processing appropriate to the type and degree of refinement required in the ultimate product. Depending upon the conditions of the market, it is often necessary to chemically convert the molecular structures of certain hydrocarbons to produce more useful or high-octane products. This conversion is accomplished by catalytic reforming, cracking or polymerization of the original molecules. The final step is treating and blending; it involves filtration to remove impurities, and mixing of various flows to achieve desired specifications.

2.29.2 Emission Sources. The major emission sources are storage tanks, regenerators or catalytic cracking units, sulphur plants, and fuel-fired process heaters and boilers.

2.29.3 Controls. Hydrocarbon losses from storage tanks were controlled by use of either cone or floating roof-type tanks. Emissions of sulphur oxides were controlled through conversion to elemental sulphur in sulphur recovery plants. In the coking and converting processes, certain plants used electrostatic precipitators and carbon monoxide boilers to reduce particulate and carbon monoxide emissions, respectively. All other operations were largely uncontrolled.

2.29.4 Emissions. Information on refinery throughputs, fuel consumed, storage emissions and catalytic cracker throughput were available from internal files (39). Emission factors obtained from the U.S. Environmental Protection Agency (4), along with internally developed information (39), were used to calculate the emissions from the above-mentioned sources. Not all plants have all operations. Emissions from fuel combustion are included in Section 3.2 under Industrial Fuel Combustion.

Total emissions for petroleum refining are presented in Table 46.

2.30 Natural Gas Processing

2.30.1 Process Description. Natural gas processing involves the removal of hydrogen sulphide and heavy hydrocarbons from the sour gas. Hydrogen sulphide is stripped from the natural gas with an amine solution and subsequently liberated, with regeneration of the original amine solution. About 95% of the hydrogen sulphide is then recovered in

TABLE 46 TOTAL EMISSIONS, PETROLEUM REFINING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	31	5 513	179	17 403	34 621
Prince Edward Island	-	-	-	-	-
Nova Scotia	1 182	10 147	347	16 058	66 966
New Brunswick[a]	-	-	-	-	-
Quebec	3 812	23 834	1 180	73 445	115 221
Ontario	3 391	36 727	1 660	30 435	104 500
Manitoba	241	2 203	71	4 953	13 666
Saskatchewan	551	1 712	94	14 408	
Alberta	2 078	3 177	777	13 427	23 430
British Columbia	1 233	9 901	435	15 805	62 870
Yukon, N.W.T.	-	-	-	-	-
TOTAL CANADA	12 519	93 214	4 743	185 934	421 274

* Expressed as SO_2

** Expressed as NO_2

a Included with Newfoundland

sulphur plants to produce elemental sulphur, while the remainder is incinerated to sulphur dioxide and released through tall stacks.

2.30.2 Emission Sources. The major sources of sulphur oxide emissions are the sulphur plant stack and the flare. Hydrocarbons are mainly emitted from storage tanks, whereas the rest of the emissions are from fuel burning (heaters, boilers, compressors).

2.30.3 Controls. By adding a tail gas unit to the sulphur plant, emissions can be greatly reduced. In 1978 only one plant used this type of unit.

2.30.4 Emissions. Sulphur dioxide emissions from natural gas processing plants were obtained from various sources (8, 53). Emission factors from the U.S. Environmental Protection Agency were used to estimate emissions of other contaminants (4). Production and fuel consumption by plant were calculated based on information obtained from numerous sources (8, 39, 81, 82, 83, 135). Emissions from fuel combustion are included in Section 3.2 under Industrial Fuel Combustion. Emissions resulting from sour oil production have not been included.

Total emissions attributable to natural gas processing are listed in Table 47.

TABLE 47 TOTAL EMISSIONS, NATURAL GAS PROCESSING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec					
Ontario		186		22	
Manitoba					
Saskatchewan		255		53	
Alberta		326 059		2 263	
British Columbia		108 391		10	
Yukon, N.W.T.					
TOTAL CANADA		434 891		2 348	

* Expressed as SO_2

** Expressed as NO_2

2.31 Tar Sands Operations

2.31.1 Process Description. The fundamental steps in extraction of bitumen from oil sands are feed conditioning, separation of the bitumen, waste disposal, and cleaning the bitumen concentrate.

Conditioning is achieved by mixing the feed with water and caustic soda at 82°C to increase its pH value. The conditioned pulp (70% solids) is pumped to separation cells where the coarse mineral matter settles and is pumped to the tailings pond. The floating bitumen froth, rich in water and fine mineral matter, is fed to the final extraction plant.

In the final extraction, the froth is diluted with coker naphtha and directed through a centrifuge. The product is distilled to remove the coker naphtha and the water from the bitumen and is upgraded by standard methods to obtain marketable products.

2.31.2 Emission Sources. The major emission source is the power plant. The fuel to the boilers is pulverized coke and at times supplemented by heavy oil. The sulphur plant is also a source of emissions. Sour gas flaring and other miscellaneous operations also contribute to the overall emissions.

2.31.3 **Controls.** Particulate emissions from the boilers are controlled by electrostatic precipitators. A sulphur plant is used to recover about 95% of the sulphur charge in the sour gases from the various process streams.

2.31.4 **Emissions.** Sulphur dioxide and nitrogen oxides emissions were provided by Alberta Environment (53, 84). Production of synthetic crude by plant was estimated using pertinent information (24, 135). Other emissions were calculated using emission factors obtained from various sources (4, 39, 46, 55).

Total emissions from tar sands operations are presented in Table 48.

TABLE 48 TOTAL EMISSIONS, TAR SANDS OPERATIONS, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydrocarbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec					
Ontario					
Manitoba					
Saskatchewan					
Alberta	9 606	107 600	13 653	9	210
British Columbia					
Yukon, N.W.T.					
TOTAL CANADA	9 606	107 600	13 653	9	210

* Expressed as SO_2
** Expressed as NO_2
Neg. - Negligible

2.32 Coal Industry

2.32.1 **Process Description.** This sector inventories emissions from coal mining, handling and transportation, as well as the coal cleaning (treatment, preparation, beneficiation) aspect of the industry. The mining of coal is carried out in either underground or surface mines. Surface mines are classed as either strip or open-pit operations. Strip mining consists of removing the overburden, extracting the coal in a series of regular slices and then replacing the overburden. Open-pit mining, usually used in mountain regions, consists of removing overburden and coal in a series of terraces that conform to the coal seams on hillsides or in deep valleys. Underground mining involves the extraction of coal from deep seams using either the conventional room and pillar or longwall techniques or the newer method of hydraulic mining. The latter technique uses a high pressure water jet to cut the coal from the underground seams.

Most of the coal mined in Canada is carried to trans-shipment or export terminals by unit trains and the coal imported into the country is shipped in lake vessels.

Coal beneficiation is used to remove impurities from coal, i.e., either unwanted rock, sulphur or both. The operation is carried out in coal preparation plants where coal may be crushed, screened, classified, washed and dried depending upon the complexity of the coal preparation operation. Not all coal mined in Canada undergoes wet preparation (approximately 65%) and not all washed coal is thermally dried. This sector covers only the thermal drying coal preparations in western Canada.

2.32.2 Emission Sources. Particulate matter in the form of coal dust and gaseous hydrocarbons from coal mines were the only contaminants considered. Fugitive dust is the major source in the mining, handling and transportation of coal, whereas the thermal dryers were the major source of emissions from the coal cleaning operations. Emissions resulting from fuel combustion for all areas of the coal industry have not been considered in this sector.

2.32.3 Controls. An average control efficiency of 91% was used for the coal cleaning operations, usually using a combination of cyclone and scrubber for the drying operation. Coal in transport was sprayed with chemical binders. Water spray is used in mining operations when operating conditions are dry.

2.32.4 Emissions. The quantities of coal mined and handled on a provincial basis were obtained from the Department of Energy, Mines and Resources (38). Emission factors of 0.013 kg/tonne for mining and 0.006 kg/tonne for handling operations were derived by the Air Pollution Control Directorate (39). Emissions from coal transportation were obtained from the same source (39). Particulate emissions from British Columbia were calculated from various sources (38, 40), whereas Alberta emissions were determined using a controlled emission factor of 0.9 kg/tonne and plant production for 1978 (4, 38, 41). Estimated emissions of methane from the mining sector were also obtained internally (39).

Total emissions resulting from the coal industry are presented in Table 49.

TABLE 49 TOTAL EMISSIONS, COAL INDUSTRY, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia	274			12 698	
New Brunswick	379			1 329	
Quebec					
Ontario	427				
Manitoba	1 656				
Saskatchewan	3 342			21 349	
Alberta	6 370			66 018	
British Columbia	67 017			52 412	
Yukon, N.W.T.					
TOTAL CANADA	79 465			153 806	

* Expressed as SO_2
** Expressed as NO_2

2.33 Metallurgical Coke Manufacture

2.33.1 Process Description. Coke is formed in an oven by driving off the volatile constituents of coal such as tar, benzene and naphthalene. Most of the volatile constituents are condensed and recovered as by-products. The hot residue, known as coke, is water quenched and dried.

In Canada, coke is manufactured primarily by the by-product process. This involves heating coal in rectangular coking ovens grouped together in a series and alternately interspersed with heating flues. The overall assembly is called a coke battery.

2.33.2 Emission Sources. Emissions from coke making arose mainly from the following operations:

- Handling, crushing and blending of coals
- Charging of coal into incandescent ovens
- Underfiring the ovens with fuels containing sulphur
- Pushing the coke out of the ovens
- Quenching of hot coke
- Handling and screening of coke

2.33.3 Controls. In most plants, all operations were partly controlled to various degrees of efficiency.

2.33.4 Emissions. Using the information on the quantities of coal used and coke produced for each coking plant (38), the emissions were calculated by emission factor techniques. The emission factors and control efficiencies were extracted from an Environment Canada report (134). Since coke oven gas is consumed also in an integrated steel plant, corrections were made to allow for coke oven gas used only in the coke plants (6).

Emission factors and total emissions from metallurgical coke manufacture are given in Tables 50 and 51 respectively.

TABLE 50 UNCONTROLLED EMISSION FACTORS, METALLURGICAL COKE MANUFACTURE

	Emission factors (kg/tonne of coal charged)				
Process	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydrocarbons	Carbon monoxide
Crushing and screening of coal and coke					
- coal	0.515				
- coke	0.045				
Charging	0.56	0.005-0.015	0.005	0.1	0.25
Pushing	0.515			0.1	0.05
Quenching	0.345				
Coking cycle	0.05		0.005	0.5	0.3
Underfiring	0.04-0.75	a			
Flaring	0.005	a			
Coke oven gas consumption	b	1.95-6.10[c]			

* Expressed as SO_2

** Expressed as NO_2

[a] Included in coke oven gas consumption.

[b] Included in underfiring.

[c] Total emission rate due to coke oven gas consumption throughout steel and coke complex.

TABLE 51 TOTAL EMISSIONS, METALLURGICAL COKE MANUFACTURE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia	1 748	2 755	2	115	152
New Brunswick					
Quebec					
Ontario	17 222	4 473	18	1 406	1 286
Manitoba					
Saskatchewan	310	318	2	77	67
Alberta					
British Columbia	671	214	1	30	38
Yukon, N.W.T.					
TOTAL CANADA	19 951	7 760	23	1 628	1 543

* Expressed as SO_2

** Expressed as NO_2

2.34 Petrochemicals

2.34.1 Process Description. Petrochemicals describe a vast number of different organic hydrocarbons. Some petrochemicals are found naturally in petroleum feed stocks but in minute quantities. Processes such as cracking or dehydrogenation are used to produce petrochemicals from the feed stock; however, conversion of the feed is not 100 percent. The separation of components is then acquired by series of absorbtion and distillation towers. Primary petrochemicals produced from petroleum and natural gas can be processed to produce other more complex petrochemicals.

2.34.2 Emission Sources. Based on the available and limited information, it appears that hydrocarbon emissions are fugitive in nature. Emission sources include atmospheric relief valves and vents, pump and valve seals, storage and transfer points. Emissions from process operations are negligible.

2.34.3 Controls. Control equipment such as water scrubbers, flares and incinerators eliminate hydrocarbon emissions from the various processes, mainly purification systems and reactors.

2.34.4 **Emissions.** Emissions were calculated using emission factors developed internally from industrial questionnaire information or were taken from literature (32, 129). Petrochemical production was obtained using plant capacities taken from the literature and petrochemical production obtained from a reliable survey (56, 130).

Total emissions from the petrochemical industry are presented in Table 52.

TABLE 52 TOTAL EMISSIONS, PETROCHEMICAL INDUSTRY, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia				573	
New Brunswick					
Quebec				12 919	
Ontario				67 986	
Manitoba				3 735	
Saskatchewan					
Alberta				79 019	
British Columbia				4 694	
Yukon, N.W.T.					
TOTAL CANADA				168 926	

* Expressed as SO_2
** Expressed as NO_2

2.35 Plastics Fabrication

2.35.1 **Process Description.** Operations primarily associated with the industry include moulding, extending and fabrication of plastics. Melt extension is commonly achieved using flat or circular dies and solvent casting. In the production of polyurethanes various organic compounds are used in conjunction with a blowing agent to vary the consistancy of the foam. These compounds vapourize upon heating of the reaction mixture. Moulding processes employ solvents, compression and injection to shape the plastics.

2.35.2 **Emission Sources.** Organic emissions result from the vapourization of the organic compounds used in the fabrication of various plastics.

2.35.3 Controls. No information with regard to control equipment was available. Organic emissions were derived assuming no controls.

2.35.4 Emissions. Emissions were calculated based on information obtained from Statistics Canada (136) and from pertinent unpublished information (133). Data on provincial productions was limited, so emissions were provincially distributed according to the number of plants in each province.

TABLE 53 TOTAL EMISSIONS, PLASTICS FABRICATION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia				243	
New Brunswick				194	
Quebec				4 905	
Ontario				10 270	
Manitoba				728	
Saskatchewan				291	
Alberta				1 190	
British Columbia				1 942	
Yukon, N.W.T.					
TOTAL CANADA				19 763	

* Expressed as SO_2
** Expressed as NO_2

2.36 Carbon Black

2.36.1 Process Description. In Canada, carbon black is produced by either the furnace or the thermal process. In the furnace process, natural gas is injected into a reactor with a limited supply of combustion air. The combustion gases are then rapidly cooled to about 260°C. The carbon black is removed from the cool gases using electrostatic precipitators, cyclones, and baghouses.

In the thermal process, natural gas is decomposed at about 1650°C in the absence of air and flame. The gas is then cooled and the carbon black is removed as in the furnace process.

2.36.2 Emission Sources. The combustion gases are the only source of process emissions, since the off-gas control equipment is an integral part of the process.

2.36.3 Controls. Particulate emissions are very low since the particulate in the gas is also the product, carbon black; hence very efficient controls are used.

In the thermal process the gaseous products are recycled, which renders the atmospheric emissions insignificant.

2.36.4 Emissions. The total production of carbon black was obtained from Statistics Canada (64). Production of carbon black by the furnace process was obtained by prorating individual plant capacities (65). The emission factors on a per plant basis were developed internally using questionnaire data (3).

Total emissions from production of carbon black are listed in Table 54.

TABLE 54 TOTAL EMISSIONS, CARBON BLACK, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec					
Ontario	18	2 490	Neg.	111	161 061
Manitoba					
Saskatchewan					
Alberta					
British Columbia					
Yukon, N.W.T.					
TOTAL CANADA	18	2 490	Neg.	111	161 061

* Expressed as SO_2
** Expressed as NO_2
Neg. - Negligible

2.37 Sulphuric Acid Production

2.37.1 Process Description. Sulphuric acid may be produced from sulphur dioxide contained in smelter off-gases or from the burning of elemental sulphur. Emissions from acid plants used in smelters are dealt with in other sections.

All sulphuric acid in Canada is produced by the Contact process. The first stage involves the production of a clean, dry gaseous mixture of sulphur dioxide and air. The dried gas mixture is then preheated and passed through a catalytic converter to form sulphur trioxide. This is absorbed into a weak sulphuric acid to produce the concentrated product.

2.37.2 Emission Sources. The major source of emissions was the waste gas from the absorber exit stack. Significant emissions may also have occurred from storage tanks and acid concentrators.

Sulphur dioxide emitted from the process, as well as acid mist escaping from the absorption tower, were the contaminants considered.

2.37.3 Controls. It was assumed that all plants had recovery equipment. Conversion of SO_2 to SO_3 varied between 95% and 99.7% (dual absorption process).

2.37.4 Emissions. Total production of sulphuric acid from sulphur burning plants was obtained through personal communication (24). Plant production was estimated using 1976 production and capacity figures. Emissions were calculated based on emission factors developed from the 1976 data.

Total emissions from sulphuric acid production are given in Table 55.

TABLE 55 TOTAL EMISSIONS, SULPHURIC ACID PRODUCTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec		1 455			
Ontario		4 194			
Manitoba		374			
Saskatchewan		674			
Alberta		10 746			
British Columbia		456			
Yukon, N.W.T.					
TOTAL CANADA		17 899			

* Expressed as SO_2

** Expressed as NO_2

2.38 Nitric Acid Production

2.38.1 Process Description. The ammonia oxidation process was the principal method of producing nitric acid in Canada in 1978. It involves the high-temperature oxidation of ammonia with air in the presence of a platinum catalyst to form nitric oxide. After cooling, additional air is required to complete the oxidation to nitrogen dioxide. The product is absorbed with water to form a weak nitric acid, which can be consumed or further concentrated by treating it with strong sulphuric acid.

2.38.2 Emission Sources. The main source of nitrogen oxides was the tail gas from the acid absorption tower. Small amounts are also emitted from the acid concentrators and storage tanks.

2.38.3 Controls. The control of nitrogen oxides depends on the age of the acid plant. New plants have greatly decreased emissions, with more efficiently designed absorption towers and nitric acid plants. It was assumed that approximately 50% of the national production of nitric acid takes place in modern plants.

2.38.4 Emissions. The 1978 production of nitric acid on a national basis was estimated using information on production and capacity obtained from published information (56). Emission factors were calculated from the questionnaire data given (3, 32).

Total emissions for nitric acid production are presented in Table 56.

2.39 Phosphoric Acid Production (Thermal Process)

2.39.1 Process Description. Phosphate rock, siliceous flux and coke are heated in an electric furnace to produce elemental phosphorus, which may then be burned and hydrated to form high-purity phosphoric acid (H_3PO_4) for industrial uses.

Only one plant manufactured thermal phosphoric acid in Canada in 1978.

2.39.2 Emission Sources. The major emission from thermal phosphoric acid production is H_3PO_4 acid mist from the absorber tail gas.

2.39.3 Controls. A scrubber and cyclone were used to control particulate emissions, with a 93% efficiency (3).

2.39.4 Emissions. Production figures and emissions for phosphoric acid (thermal process) were projected to 1978 values from data provided for 1976 (3).

Emissions from thermal process phosphoric acid production are listed in Table 57.

TABLE 56 TOTAL EMISSIONS, NITRIC ACID PRODUCTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec			399		
Ontario			1 249		
Manitoba			584		
Saskatchewan					
Alberta			4 712		
British Columbia					
Yukon, N.W.T.					
TOTAL CANADA			6 944		

* Expressed as SO_2
** Expressed as NO_2

TABLE 57 TOTAL EMISSIONS, PHOSPHORIC ACID PRODUCTION (THERMAL PROCESS), 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec	71				
Ontario					
Manitoba Saskatchewan					
Alberta					
British Columbia					
Yukon, N.W.T.					
TOTAL CANADA	71				

* Expressed as SO_2
** Expressed as NO_2

2.40 Phosphate Rock Processing

2.40.1 Process Description. Mined ore is usually beneficiated, crushed and categorized according to the purchaser's specifications. These intermediate steps in the mining of phosphate rock are not included in this assessment because all the phosphate rock used in Canada is imported, and upgrading of the rock is usually done at the mine. Similarly, drying of phosphate rock is usually carried out at the mine.

Of concern here is that most fertilizer and elemental phosphorus plants grind the phosphate rock prior to its use in fertilizer and elemental phosphorus production.

2.40.2 Emission Sources. Emissions in the form of fine rock dust occur mainly from grinding and material-handling operations.

2.40.3 Controls. Questionnaire information obtained from fertilizer plants indicated that baghouses were used to control particulate emissions. One plant also used a scrubber. For phosphorous manufacturers, the use of scrubbers was assumed.

2.40.4 Emissions. Emission factors were obtained from industrial questionnaire replies (32). Data specific to phosphorous manufacturing plants were not available; hence, emission factors developed for the fertilizer industry were assumed to hold for these plants as well. The quantities of phosphate rock used in each province were estimated based on questionnaire data, engineering judgment and unpublished information (8, 32, 59, 60).

Emission factors and total emissions for phosphate rock processing are presented in Tables 58 and 59 respectively.

TABLE 58 CONTROLLED EMISSION FACTORS, PHOSPHATE ROCK PROCESSING

	Emission factors (kg/tonne rock)
Process	Particulate Matter
Grinding Transfer and storage Enclosed storage piles	0.14

TABLE 59 TOTAL EMISSIONS, PHOSPHATE ROCK PROCESSING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	59				
Prince Edward Island					
Nova Scotia					
New Brunswick	22				
Quebec	15				
Ontario	79				
Manitoba					
Saskatchewan					
Alberta	170				
British Columbia	70				
Yukon, N.W.T.					
TOTAL CANADA	415				

* Expressed as SO_2
** Expressed as NO_2

2.41 Phosphate Fertilizer Production

2.41.1 Process Description. Phosphate fertilizers are produced by decomposing phosphate rock with a strong mineral acid.

Single superphosphate is the product of acidulation of phosphate rock with sulphuric acid and involves three basic steps. Acid and phosphate rock are mixed, dropped into a curing den, held for sufficient time to allow the slurry to set into a solid porous form and stored to permit the acidulation to go to completion. After the curing period, the product is usually granulated and dried.

The production of triple superphosphate is similar to that of single superphosphate, the difference being that phosphoric acid is used for acidulation.

Ammonium phosphates are produced when phosphoric acid is treated or neutralized with ammonia under controlled conditions. The material is then dried and cooled prior to screening.

Nine companies were producing phosphate fertilizers in 1978.

2.41.2 Emission Sources. The major sources of particulate emissions are the granulators, dryers, coolers and screens. Gases are also released from the acid/phosphate rock reaction tanks and contain mainly silicon tetrafluorides, carbon monoxide and some particulates; however, due to a lack of information, emissions could not be estimated for this source.

2.41.3 Controls. All phosphate fertilizer manufacturing plants had some type of air pollution control equipment. Granulation, drying and cooling operations were usually controlled by wet scrubbers, baghouses and cyclones with an estimated average control efficiency of 95%. This control efficiency was estimated because of unavailable and conflicting information.

2.41.4 Emissions. Emissions from ammonium phosphate fertilizer plants were calculated using published emission factors (4). Production figures were calculated using industrial questionnaire replies and Statistics Canada data (32, 61, 62). Emission factors for single and triple superphosphate manufacture were based on data from the U.S. Environmental Protection Agency (4). Production figures were calculated using published information and engineering practices (63).

Emission factors and total emissions for phosphate fertilizer production are listed in Tables 60 and 61 respectively.

TABLE 60 UNCONTROLLED EMISSION FACTORS, PHOSPHATE FERTILIZER PRODUCTION

	Emission factors (kg/tonne of product)	
	Particulate Matter	
Source	Ammonium Phosphates	Superphosphates
Material handling	1	1
Screening	1	1
Ammoniator-granulator	15	-
Drying	27.5	52.5
Cooling	-	45.0
Product grinding	-	0.25

2.42 Elemental Phosphorus Production

2.42.1 Process Description. The production of elemental phosphorus involves two main operations: feed preparation and smelting of phosphate rock.

TABLE 61 TOTAL EMISSIONS, PHOSPHATE FERTILIZER PRODUCTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick	336				
Quebec					
Ontario	708				
Manitoba	271				
Saskatchewan					
Alberta	2 688				
British Columbia	298				
Yukon, N.W.T.					
TOTAL CANADA	4 301				

* Expressed as SO_2
** Expressed as NO_2

Phosphate rock is finely ground, wetted and pelletized. The pellets are fired in a kiln, cooled and stored. The other components of the furnace feed, coke and silica, undergo only cleaning and drying.

Elemental phosphorus is produced by smelting the pellets with coke and silica in an electric furnace. A slag of calcium silicate and ferrophosphorus is periodically tapped from the furnace. Phosphorus vapour is condensed and stored under water, whereas carbon monoxide is either flared or used as a fuel in preparing the furnace charge.

Two plants were producing elemental phosphorus in Canada in 1978. One of them pelletized the phosphate rock for both plants.

2.42.2 Emission Sources. In the feed preparation area, the exhaust gas from the pelletizer plant is a major source of particulate emissions. Significant emissions also occur from the coke and silica drying plant, from the screening of coke and transfer points, and from feed proportioning.

2.42.3 Controls. Both plants had some type of air pollution control equipment. Silica/coke drying operations were controlled by cyclones, whereas emissions from the pellet plant were controlled by scrubbers and a baghouse.

Exhaust gases from the electric furnace, containing phosphorus vapour, carbon monoxide and dust, were passed through an electrostatic precipitator or scrubbed at one plant, while the other one was uncontrolled.

2.42.4 Emissions. Plant production was calculated based on information provided by the Department of Energy, Mines and Resources (59). Emissions were calculated based on emission factors derived from 1976 emissions.

Total emissions attributable to elemental phosphorus production are presented in Table 62.

TABLE 62 TOTAL EMISSIONS, ELEMENTAL PHOSPHORUS PRODUCTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	7 121	1 377			
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec	3 554	738			
Ontario					
Manitoba					
Saskatchewan					
Alberta					
British Columbia					
Yukon, N.W.T.					
TOTAL CANADA	10 675	2 115			

* Expressed as SO_2

** Expressed as NO_2

2.43 Nitrate Fertilizer Production

2.43.1 Process Description. The basic material used in the production of nitrate fertilizer is anhydrous ammonia.

Ammonium nitrate is produced by neutralizing nitric acid with ammonia, with subsequent concentration by evaporation. The resulting solution is then formed into granules by the use of prilling towers.

Another nitrate fertilizer, urea, is produced by reacting liquid ammonia and liquid carbon dioxide at relatively high pressure. The resulting liquor is dehydrated and solidified by prilling or granulating.

2.43.2 Emission Sources. Major emission sources are prilling towers and granulators. Particulate matter can also be produced in the drying, cooling and material-handling operations.

2.43.3 Controls. Wet or dry cyclones are usually used for various granulating, drying and cooling operations in order to recover valuable product. A control efficiency of 85% on particulates was assumed.

2.43.4 Emissions. Total Canadian production of ammonium nitrate and urea was obtained from Statistics Canada (62).

Production at each plant was estimated by prorating available questionnaire information to the base year 1978 (32). Emission factors were taken from a U.S. Environmental Protection Agency publication and available questionnaire data (4, 32).

Emission factors and total emissions for nitrate fertilizer are presented in Tables 63 and 64 respectively.

TABLE 63 CONTROLLED EMISSION FACTORS, NITRATE FERTILIZER PRODUCTION

	Emission factors (kg/tonne of product)		
	Particulate Matter		
Source	Ammonium Nitrate	Urea	Nitrogen oxides*
Neutralizer	1.60		0.19
Evaporator/Concentrator	0.47	0.47	
Prilling Tower	3.20	0.75	
Dryer and Cooler	0.05	0.05	
Granulator		0.18	0.45
Dryer and Cooler		-	1.50
Bulk Loading	0.01	0.01	

* Expressed as NO_2 (for ammonium nitrate only)

TABLE 64 TOTAL EMISSIONS, NITRATE FERTILIZER PRODUCTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec					
Ontario	2 850		77		
Manitoba	640		20		
Saskatchewan					
Alberta	3 207		73		
British Columbia					
Yukon, N.W.T.					
TOTAL CANADA	6 697		170		

* Expressed as SO_2
** Expressed as NO_2

2.44 Grain Handling

2.44.1 Process Description. Grain elevators are primarily transfer and storage units and are classified either as primary, terminal, transfer or process elevators.

The principal function of the primary elevators is to receive grain directly from producers for either storage or forwarding, or both. At terminal elevators, cleaning, storing and treating of grain takes place prior to shipment. Each receipt or shipment is weighed and inspected. Transfer elevators generally include the same operations as terminal elevators. Process elevators are used for receipt and storage of grain for direct manufacture or processing into other products.

2.44.2 Emission Sources. The only significant air contaminant from grain elevators is particulate matter and results mainly from grain-handling operations. The amount of dust emitted during the various grain-handling operations depends upon the type of grain being handled, its quality or grade, its moisture content, the degree of enclosure at loading and unloading areas, and the extent and efficiency of dust containment systems used.

2.44.3 Controls. Dust collection systems were generally applied to most phases of grain-handling operations to reduce product and component losses. An overall control efficiency of 75% was assumed on primary and process elevators, and 90% for terminal and transfer elevators. It was assumed that only 25% of receipts in primary elevators are dried and 10% are cleaned.

2.44.4 Emissions. Emissions from primary, terminal and transfer elevators were based on the quantities of grain received at licensed elevators. Throughput for these types of elevators was taken to be the same as receipts given in the literature (87). Grain receipts at process elevators were assumed to be in the same ratio as grain receipts were to grain capacities for terminal and transfer elevators (88). A provincial breakdown was made on the basis of grain storage capacity of process elevators as found in pertinent literature (88). All emission factors were taken from internal unpublished data (89).

Emission factors and total emissions for grain-handling and grain milling operations are presented in Tables 65 and 66 respectively.

2.45 Grain Milling

2.45.1 Process Description. The grain milling industry includes establishments engaged in milling flour or meals from grain. Commercial flour milling in Canada is carried out by numerous companies.

Only the milling of wheat is included in this survey. The process consists of four main operations: reception and storage of wheat, cleaning and conditioning, milling of wheat into flour and into its by-products, and storage or shipment of finished product.

2.45.2 Emission Sources. The major emission sources are wheat-cleaning and milling operations. Dust emissions associated with receiving and handling of wheat are also included.

The contaminant considered for these sources is particulate matter.

2.45.3 Controls. Due to the economic value of the products, the extent of control is high. Baghouses, 97% efficient, are used in the control of the milling operation, while either cyclones, baghouses, or no control at all was assumed for all other operations with an average efficiency of 75%.

2.45.4 Emissions. The capacities of grain mills for wheat were obtained from the literature (90). The mills were assumed to operate 5 days per week, 52 weeks per year. Emissions were calculated using emission factors based on published data and other internal sources (32, 91).

Emission factors and total emissions for grain milling are included in Tables 65 and 66 respectively.

TABLE 65 UNCONTROLLED EMISSION FACTORS, GRAIN HANDLING AND MILLING

Process	Emission factors (kg/tonne of grain) Particulate Matter
PRIMARY ELEVATORS	
Unloading (receiving)	0.32
Loading (shipping)	0.14
Removal from bins	1.47
Drying	0.34
Headhouse (legs)	2.32
	4.59
TERMINAL ELEVATORS	
Unloading (receiving)	0.50
Loading (shipping)	0.14
Removal from bins (tunnel belt)	1.40
Drying	0.52
Cleaning	3.60
Headhouse (legs)	3.00
Tripper (gallery belt)	0.85
	10.01
TRANSFER ELEVATORS	
Unloading (receiving)	0.50
Loading (shipping)	0.50
Removal from bins	0.84
Drying	-
Cleaning	-
Headhouse (legs)	1.65
Tripper (gallery belt)	0.55
	4.04
PROCESS ELEVATORS AND WHEAT MILLS	
Unloading (receiving)	0.50
Precleaning and handling	2.50
Cleaning house	0.20
Millhouse	35.00
	38.20

TABLE 66 TOTAL EMISSIONS, GRAIN HANDLING AND MILLING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia	200				
Brunswick	119				
Quebec	7 451				
Ontario	15 488				
Manitoba	6 952				
Saskatchewan	17 640				
Alberta	8 816				
British Columbia	8 384				
Yukon, N.W.T.					
TOTAL CANADA	65 050				

* Expressed as SO_2
** Expressed as NO_2

2.46 Bakeries

2.46.1 Process Description. Bakery goods can be divided between products leavened by yeast and products leavened by baking powder. Emissions from products leavened by baking powder which is used mainly for pastries are negligible. Hydrocarbons are however released with yeast, which is used nearly exclusively in bread baking.

Two processes are used commercially for baking bread: the straight-dough process and the sponge-dough process. The difference between the processes occurs during the fermentation stage. Straight dough is fermented containing all ingredients whereas sponge dough is fermented with only part of the ingredients; the remainder is added only before baking. The fermentation process takes from 2-4 hours and the baking temperature is generally maintained around 230°C. Most commercial bakeries employ the sponge dough process.

2.46.2 Emission Sources. During fermentation carbon dioxide and ethanol are produced. The carbon dioxide remains in the bread while the ethanol volatilizes. Ethanol is also released to the atmosphere during the baking stage.

2.46.3 Controls. No controls are employed.

2.46.4 Emissions. The production of bread was obtained from a Statistics Canada publication while emission factors were taken from a U.S. Environmental Protection Agency publication (1, 131).

Total emissions for bakeries are presented in Table 67.

TABLE 67 TOTAL EMISSIONS, BAKERIES, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland				46	
Prince Edward Island				5	
Nova Scotia				114	
New Brunswick				91	
Quebec				1 226	
Ontario				1 423	
Manitoba				139	
Saskatchewan				84	
Alberta				245	
British Columbia				374	
Yukon, N.W.T.				2	
TOTAL CANADA				3 749	

* Expressed as SO_2
** Expressed as NO_2

2.47 Sulphate (Kraft) Pulping

2.47.1 Process Description. The sulphate (kraft) process is used to produce most of the pulp in Canada and involves the 'cooking' of wood chips under pressure in an aqueous solution of sodium hydroxide and sodium sulphide. The slurry of pulp fibres from the cooking process is washed to recover dissolved wood and spent pulping chemicals. The fibre slurry passes through a knotter, where unreacted chunks of wood are removed. A large portion of the wood pulp is then bleached, before being pressed and dried into the finished product. The spent liquor from the washers, known as black liquor, contains the cooking chemicals and about half the original water in the wood. It is evaporated to remove most of the water and sprayed into a recovery boiler, where its organic content supports combustion. The inorganic compounds are withdrawn as a molten smelt which is then processed to produce pulping chemicals to be recycled in the process.

2.47.2 Emission Sources. Several steps in the pulping and chemical recovery process resulted in the production of significant quantities of air emissions. The major emission sources were the recovery boiler, the smelt dissolving tank and the lime kiln.

The contaminants considered for these sources were particulate matter, sulphur oxides, nitrogen oxides and carbon monoxide.

2.47.3 Controls. Most of the kraft pulping plants in Canada had some type of air pollution control equipment. Electrostatic precipitators on recovery furnaces and wet scrubbers on lime kilns were the most widely used. Smelt dissolving tanks had mesh pads (usually with intermittent showers). All kraft pulp mills in Canada operated chemical recovery systems.

2.47.4 Emissions. Production figures from kraft pulping operations were obtained from various sources (3, 8). Controlled emission factors, except for nitrogen oxides, were developed by the Air Pollution Control Directorate. The types of control equipment used and their efficiencies were obtained from industrial questionnaire replies. The nitrogen oxides emission factor was based on a U.S. EPA report (52). Sulphur dioxide emissions from Alberta were obtained from an Alberta Environment report (53).

Emission factors and total emissions for sulphate (kraft) pulping are listed in Tables 68 and 69 respectively.

TABLE 68 CONTROLLED EMISSION FACTORS, SULPHATE (KRAFT) PULPING

	Emission factors (kg/ADMT pulp*)			
Process	Particulate Matter**	Sulphur oxides***	Nitrogen oxides****	Carbon monoxide
Recovery boiler		2.5	0.95	1.5
Smelt dissolving tank				
Lime kiln			0.75	0.5

* ADMT: air dried metric tonne

** Particulate emission factors calculated separately for each plant.

*** Expressed as SO_2

**** Expressed as NO_2

TABLE 69 TOTAL EMISSIONS, SULPHATE (KRAFT) PULPING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia	4 195	518	351	191	413
New Brunswick	8 913	1 507	991	790	1 183
Quebec	17 971	3 781	2 451	1 910	2 945
Ontario	18 275	4 777	3 248	2 537	3 823
Manitoba	740	311	211	165	249
Saskatchewan	4 465	691	470	367	553
Alberta	3 658	11 986	845	660	994
British Columbia	47 503	11 670	7 933	6 135	9 342
Yukon, N.W.T.					
TOTAL CANADA	105 720	35 241	16 500	12 755	19 502

* Expressed as SO_2

** Expressed as NO_2

2.48 Sulphite Pulping

2.48.1 Process Description. Sulphite pulping is accomplished by heating wood chips under pressure in an aqueous solution of cooking liquor to produce a fibrous slurry. The cooking liquor, or acid, is produced by burning sulphur and absorbing the sulphur dioxide in an alkaline base solution such as carbonate or hydroxide of calcium, magnesium, sodium or ammonia. Before the raw acid is used in pulping it is fortified with relief gases of sulphur dioxide from the digester. Upon completion of the cooking cycle the contents of the digester are discharged into a blow tank. The pulp then goes through a washing stage, where spent liquor is separated from the fibres and the pulp is cleaned before being bleached or used directly in the end products.

2.48.2 Emission Sources. Sulphur oxides were the principal contaminant from the sulphite process and originate from the cooking and acid-making operations. The major sources of emissions were the absorption towers, blow pits or dump tanks, and spent sulphite liquor combustion units when chemical recovery systems were used.

2.48.3 Controls. Most of the sulphite pulping facilities were old and small and have very little emission control equipment. Blowing emissions from the digester were inadequately controlled by the water showers in the blow tank vents. Five plants had chemical recovery systems in 1978, three bisulphite plants and two acid sulphite plants; however, one acid sulphite plant did shut down in the third quarter of 1978. Control in the recovery boiler was carried out by flue-gas scrubbers, the primary purpose of which was recovering sulphur dioxide for cooking acid manufacture.

2.48.4 Emissions. Production figures from sulphite pulping operations were obtained from various sources (3, 8). Uncontrolled emission factors were estimated internally and were based on a U.S. Environmental Protection Agency publication and reported industry data (4, 54). An average emission factor of 22.5 kg SO_x/ADMT pulp was used for acid sulphite plants with chemical recovery and 43.5 kg SO_x/ADMT without chemical recovery. For bisulphite plants, an emission factor of 22.5 kg/ADMT was used for plants both with and without recovery furnaces.

Emission factors and total emissions for sulphite pulping are given in Tables 70 and 71 respectively.

TABLE 70 UNCONTROLLED EMISSION FACTORS, SULPHITE PULPING

	Emission factors (kg/ADMT pulp*)		
		Sulphur oxides***	
Process	Particulate matter	Acid sulphite pulp	Bisulphite pulp
Digester discharge		33.5	12.5
Absorption tower		5-10[a]	5-10[a]
SSL** combustion	2.5	10-15[a]	10-15[a]
Miscellaneous		2.5	2.5

* ADMT: air dried metric tonne
** SSL: spent sulphite liquor
*** Expressed as SO_2
[a] After primary scrubbing

2.49 Sawmills

2.49.1 Process Description. Sawmills transform logs into cut lumber. The logs are debarked and then cut into the desired lumber. This lumber is subsequently planed to remove rough surfaces produced by the cutting process.

TABLE 71 TOTAL EMISSIONS, SULPHITE PULPING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland		3 269			
Prince Edward Island					
Nova Scotia	507	5 261			
New Brunswick		8 674			
Quebec	324	34 940			
Ontario	271	13 029			
Manitoba		834			
Saskatchewan					
Alberta					
British Columbia	340	3 063			
Yukon, N.W.T.					
TOTAL CANADA	1 442	69 070			

* Expressed as SO_2
** Expressed as NO_2

2.49.2 Emission Sources. Emissions of particulate matter in sawmills originate from sawing and planing operations as well as from sawdust handling and storage.

2.49.3 Controls. Emission controls consist of cyclones and baghouses. Cyclones are commonly used while baghouses are occasionally added as a secondary control device.

2.49.4 Emissions. Emissions were calculated using emission factors from U.S. studies and lumber production from published data (4, 132).

Total emissions from sawmills are presented in Table 72.

2.50 Pulp Board

2.50.1 Process Description. Pulp board is the term applied to boards made from pulp slurry. Two types of boards are produced, paper board and fibre board; however, emissions from paper board production appear to be negligible.

In the production of fibre board, pulping slurry is washed then sent to stock chests where sizing is added. The refined fibre material is fed to the board machine and through the forming screens and is subsequently dried. The final product is cut to size and sanded.

TABLE 72 TOTAL EMISSIONS, SAWMILLS, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydrocarbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia	575				
New Brunswick	1 273				
Quebec	10 367				
Ontario	5 240				
Manitoba					
Saskatchewan	717				
Alberta	1 977				
British Columbia	40 851				
Yukon, N.W.T.					
TOTAL CANADA	61 000				

* Expressed as SO_2
** Expressed as NO_2

2.50.2 Emission Sources. Particulates are emitted from cutting and sanding, and drying operations. Hydrocarbons are emitted exclusively from the dryer.

2.50.3 Controls. As in most other wood products industries, the particulates generated at the various processing stages are removed and collected with the aid of cyclones or occasionally baghouses.

2.50.4 Emissions. Emissions were calculated using emission factors taken from U.S. Environmental Protection Agency publications (4). Production of pulpwood was obtained from published data (132).

Total emissions from pulpboard manufacture are presented in Table 73.

2.51 Plywood and Veneer

2.51.1 Process Description. Plywood is composed of thin layers of wood (veneers) bonded together with an adhesive. Plywood production begins with logs which are debarked and cut into veneers. The veneers are initially dried to reduce the moisture content. The dried veneers are then sorted, assembled and bonded together. The resulting plywood is steam pressed, trimmed and sanded.

TABLE 73 TOTAL EMISSIONS, PULPBOARD MANUFACTURE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick	107			9	
Quebec	364			29	
Ontario	828			66	
Manitoba					
Saskatchewan	132			11	
Alberta	154			12	
British Columbia	185			15	
Yukon, N.W.T.					
TOTAL CANADA	1 770			142	

* Expressed as SO_2

** Expressed as NO_2

2.51.2 Emission Sources. Particulate emissions consisting of sawdust and wood particles are liberated by sawing, debarking, cutting and sanding operations. Further emissions result from the handling and storage of sawdust. Hydrocarbon emissions are emitted primarily from the veneer dryers.

2.51.3 Controls. Cyclones are occasionally used to control the particulate emissions produced by most of the processes.

2.51.4 Emissions. Production of plywood was obtained from published data (132). Emissions were calculated using emission factors taken from various American studies (1).

Total emissions from plywood and veneer manufacture are presented in Table 74. Table 74(T) summarizes the emissions from the three wood industry sectors (Sections 2.49, 2.50, 2.51).

TABLE 74 TOTAL EMISSIONS, PLYWOOD AND VENEER MANUFACTURE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	4			Neg.	
Prince Edward Island					
Nova Scotia					
New Brunswick	65			2	
Quebec	590			21	
Ontario	1 085			38	
Manitoba					
Saskatchewan	141			5	
Alberta	632			22	
British Columbia	5 810			206	
Yukon, N.W.T.					
TOTAL CANADA	8 327			294	

* Expressed as SO_2

** Expressed as NO_2

TABLE 74(T) TOTAL EMISSIONS, WOOD INDUSTRY, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	4				
Prince Edward Island					
Nova Scotia	575				
New Brunswick	1 445			11	
Quebec	11 321			50	
Ontario	7 153			104	
Manitoba					
Saskatchewan	990			16	
Alberta	2 763			34	
British Columbia	46 846			221	
Yukon, N.W.T.					
TOTAL CANADA	71 097			436	

* Expressed as SO_2

** Expressed as NO_2

3 EMISSIONS FROM FUEL COMBUSTION - STATIONARY SOURCES

Coal and petroleum fuel consumption data are grouped into categories of power generation by utilities, industrial use, commercial use, and residential use.

3.1 Power Generation by Utilities

3.1.1 General. This sector encompasses emissions from the generation of electricity by publicly and privately owned utilities. Power generation by sources other than utilities is covered under the appropriate fuel type. Emissions resulting from steam generation at utilities for heavy water production are also included.

There are two basic methods of generating thermal power from fossil fuels: steam generating systems and internal combustion systems (gas turbine and reciprocating engines). Steam turbine boilers may be fired by coal, heavy fuel oil, crude oil or natural gas (initial steam may be raised by light fuel oil or natural gas). Gas turbines may be fired by light oil, natural gas, kerosene or diesel oil , whereas reciprocating engines may be fuelled by light oil, natural gas, a combination of both, or by diesel oil.

3.1.2 Emissions. Information on fuel consumption, ash and sulphur content, controls and emissions were obtained from a multitude of sources (7, 10, 45, 53, 84, 92, 93, 94, 95). For the province of Alberta, the sulphur and nitrogen oxide emissions data were supplied by Alberta Environment (53, 84). Emissions were provided by the province or calculated using emission factors taken from a U.S. Environmental Protection Agency publication (4), or developed internally for Canadian conditions (45). Power generation utilities generally had emission control equipment for particulates with a wide range of efficiencies. Several old stations were uncontrolled.

Total emissions attributable to power generation by utilities are given in Table 75.

3.2 Industrial Fuel Combustion

3.2.1 General. This section estimates the emissions resulting from the combustion of fuels in industrial establishments. The fuels included are natural gas, heavy fuel oil, light fuel oil, stove oil and kerosene, liquid petroleum gases and coal.

3.2.2 Emissions. Fuel consumption quantities were available on a provincial basis from a Statistics Canada publication (43). Ash and sulphur content of fuels used in various provinces were obtained from the literature (96) or elsewhere (70). Emission factors were taken from a U.S. Environmental Protection Agency publication (4).

TABLE 75 TOTAL EMISSIONS, POWER GENERATION BY UTILITIES, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	1 031	12 720	2 807	158	565
Prince Edward Island	231	3 013	1 045	9	53
Nova Scotia	10 675	112 983	39 851	313	1 252
New Brunswick	5 747	85 653	17 325	190	921
Quebec	314	1 959	2 366	211	692
Ontario	13 468	437 740	91 867	1 434	5 049
Manitoba	7 084	3 773	3 675	139	457
Saskatchewan	64 453	36 998	37 697	756	2 568
Alberta	59 814	35 073	35 764	1 216	4 371
British Columbia	143	225	1 627	149	488
Yukon, N.W.T.	260	421	2 901	280	905
TOTAL CANADA	163 220	730 558	236 925	4 855	17 321

* Expressed as SO_2

** Expressed as NO_2

Given the limited amount of data available and conflicting information, it was not possible to estimate the emissions in this sector for individual processes other than petroleum refining, natural gas processing and clay products manufacture. For these processes, the appropriate emission factors and corresponding emissions have been shown separately. It should be noted that in Table 77, the emissions totals shown represent the emissions for the whole industrial fuel combustion sector including those for petroleum refining, natural gas processing and clay products manufacture.

Emission factors and emissions due to industrial fuel combustion are presented in Tables 76 to 80.

3.3 Commercial Fuel Combustion

3.3.1 General. Emissions due to the combustion of fuel in commercial establishments are estimated in this section. The same types of fuels used for industrial fuel combustion are considered, with the exception of coal, propane and butane.

3.3.2 Emissions. Fuel consumption figures were obtained from Statistics Canada (43). Emission factors were based on a U.S. Environmental Protection Agency publication (4).

TABLE 76 UNCONTROLLED EMISSION FACTORS, INDUSTRIAL FUEL COMBUSTION (FOR UNIDENTIFIED INDUSTRIAL SOURCES)

Source	Emissions factors (kg/10^3 litres)				
	Particulate matter	Sulphur oxides (as SO_2)	Nitrogen oxides (as NO_2)	Hydro-carbons	Carbon monoxide
Natural gas[a]	160	9.6	2 800	48	272
Liquid petroleum gases[b]	0.22	0.00366	1.35	0.036	0.18
Light fuel oil[c]	0.25	8.5[f] 5.1[g]	2.8	0.12	0.63
Heavy fuel oil[c]	3.505[f] 2.88[g]	47.5[f] 38.0[g]	11.25	0.12	0.63
Stove oil and kerosene[c]	0.25	8.5[f] 5.1[g]	2.8	0.12	0.63
Coal[d]	10.4-19.5[e]	11.4-133.0[e]	7.5	0.5	1.0

[a] Emission factors expressed as kg/10^6 m^3

[b] From reference (4) under "Liquefied Petroleum Gas Consumption"

[c] From reference (4) under "Fuel Oil Combustion"

[d] Emission factors expressed as kg/tonne

[e] Emission factors vary by province, depending upon the ash and sulphur content of coals used.

[f] Eastern Canada

[g] Western Canada

Emission factors and total emissions from commercial fuel combustion are presented in Tables 81 and 82 respectively.

3.4 Residential Fuel Combustion

3.4.1 General. In this section fuels consumed mainly for residential heating and air conditioning are considered.

3.4.2 Emissions. Fuel consumption quantities for heavy fuel oil, light fuel oil, coal, natural gas, liquid petroleum gas, and stove oil and kerosene were obtained from Statistics Canada (43). Emission factors were taken from a U.S. Environmental Protecton Agency publication (4). Ash and sulphur content of fuels used in various provinces were either obtained from the literature (96) or elsewhere (70).

TABLE 77 TOTAL EMISSIONS, INDUSTRIAL FUEL COMBUSTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	1 936	26 854	6 346	84	363
Prince Edward Island	31	444	114	2	9
Nova Scotia	2 079	30 761	6 783	542	1 485
New Brunswick	3 338	44 876	9 766	315	449
Quebec	23 422	246 793	60 970	1 979	3 534
Ontario	18 310	176 367	72 945	2 095	4 901
Manitoba	2 198	7 541	4 401	180	391
Saskatchewan	1 661	6 692	7 073	177	475
Alberta	2 206	14 346	130 054	43 352	16 106
British Columbia	4 121	48 226	21 487	1 073	1 319
Yukon, N.W.T.	22	343	195	9	39
TOTAL CANADA	59 324	603 243	320 134	49 808	29 071

* Expressed as SO_2
** Expressed as NO_2

TABLE 78 FUEL COMBUSTION EMISSIONS, PETROLEUM REFINING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	570	12 212	2 788	231	
Prince Edward Island	-	-	-	-	
Nova Scotia	602	12 743	2 775	215	
New Brunswick[a]	-	-	-	-	
Quebec	2 841	51 409	12 264	1 096	
Ontario	3 226	53 380	13 867	792	
Manitoba	129	2 774	642	54	
Saskatchewan	135	2 876	648	53	
Alberta	1 069	13 545	5 675	510	
British Columbia	633	14 321	3 892	390	
Yukon, N.W.T.	-	-	-	-	
TOTAL CANADA	9 205	163 260	42 551	3 341	

* Expressed as SO_2
** Expressed as NO_2
a Included with Newfoundland

TABLE 79 FUEL COMBUSTION EMISSIONS, NATURAL GAS PROCESSING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec					
Ontario	11	167	830	232	72
Manitoba					
Saskatchewan	6	Neg.	1 717	2	Neg.
Alberta	337	106	111 485	42 611	14 819
British Columbia	46	Neg.	2 213	449	164
Yukon, N.W.T.			Neg.	1	Neg.
TOTAL CANADA	400	273	116 245	43 295	15 055

* Expressed as SO_2
** Expressed as NO_2

TABLE 80 FUEL COMBUSTION EMISSIONS, CLAY PRODUCTS MANUFACTURE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	3	54	6	1	
Prince Edward Island					
Nova Scotia	30	498	57	4	
New Brunswick	13	219	25	1	
Quebec	116	1 877	220	18	2
Ontario	97	996	230	22	23
Manitoba			1		
Saskatchewan	2		15	1	2
Alberta	4		19	2	4
British Columbia	4	27	13	1	2
Yukon, N.W.T.					
TOTAL CANADA	269	3 671	586	50	33

* Expressed as SO_2
** Expressed as NO_2

TABLE 81 UNCONTROLLED EMISSION FACTORS, COMMERCIAL FUEL COMBUSTION

Source	Emission factors ($kg/10^3$ litres)					
	Particulate matter		Sulphur oxides*	Nitrogen oxides**	Hydrocarbons	Carbon monoxide
Natural gas[a]	160		9.6	1 920	128	320
Light fuel oil[b]	0.25	E. Canada	8.5	2.8	0.12	0.63
		W. Canada	5.1			
Heavy fuel oil[b] E. Canada	3.505	E. Canada	47.5	11.25	0.12	0.63
W. Canada	2.88	W. Canada	38.0			
Stove oil and kerosene[b]	0.25	E. Canada	8.5	2.8	0.12	0.63
		W. Canada	5.1			

* Expressed as SO_2
** Expressed as NO_2
[a] Emission factors expressed as $kg/10^6$ m^3
[b] From reference (4) under "Fuel Oil Combustion"

TABLE 82 TOTAL EMISSIONS, COMMERCIAL FUEL COMBUSTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydrocarbons	Carbon monoxide
Newfoundland	189	3 338	911	23	123
Prince Edward Island	34	686	197	6	32
Nova Scotia	628	9 650	2 461	47	243
New Brunswick	313	5 169	1 366	30	162
Quebec	3 931	60 551	16 450	367	1 776
Ontario	2 109	22 560	14 860	637	2 117
Manitoba	1 247	2 202	2 328	141	353
Saskatchewan	96	178	1 143	74	196
Alberta	494	260	5 883	389	984
British Columbia	403	3 495	3 244	161	488
Yukon, N.W.T.	32	554	265	9	53
TOTAL CANADA	9 476	108 643	49 108	1 884	6 527

* Expressed as SO_2
** Expressed as NO_2

Emission factors and total emissions due to residential fuel combustion are given in Tables 83 and 84 respectively.

TABLE 83 UNCONTROLLED EMISSION FACTORS, RESIDENTIAL FUEL COMBUSTION

	Emission factors (kg/10^3 litres)						
Source		Particulate matter		Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Natural gas[a]		160		9.6	1 280	128	320
Liquid petroleum gases[b]		0.22		0.00366	0.80	0.084	0.23
Light fuel oil[c]		0.31	E. Canada	8.5	2.3	0.12	0.63
			W. Canada	5.1			
Heavy fuel oil[c]	E. Canada	3.505	E. Canada	47.5	11.25	0.12	0.63
	W. Canada	2.88	W. Canada	38.0			
Stove oil and kerosene[c]		0.31	E. Canada	8.5	2.3	0.12	0.63
			W. Canada	5.1			
Coal[d]		10.0		11.4-133.0[e]	1.5	10.0	45.0

* Expressed as SO_2
** Expressed as NO_2
[a] Emission factors expressed as kg/10^6 m^3
[b] From reference (4) under "Liquefied Petroleum Gas Consumption"
[c] From reference (4) under "Fuel Oil Combustion"
[d] Emission factors expressed as kg/tonne
[e] Emission factors vary by province, depending upon the sulphur content of coals used.

3.5 Fuelwood Combustion

3.5.1 General. This section included emissions from the use of wood as a fuel in small commercial and residential stoves, furnaces and fireplaces.

3.5.2 Emissions. Primary forest fuelwood production for each province in 1978 was taken from the literature (97). Emissions were developed using emission factors obtained from a U.S. Environmental Protection Agency Publication (4) and from internal data (45).

Emission factors and total emissions attributable to fuelwood combustion are listed in Tables 85 and 86 respectively.

TABLE 84 TOTAL EMISSIONS, RESIDENTIAL FUEL COMBUSTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	128	3 533	957	50	262
Prince Edward Island	43	1 151	315	16	86
Nova Scotia	770	10 308	2 302	538	2 496
New Brunswick	217	5 504	1 475	85	439
Quebec	2 496	50 142	13 849	618	3 030
Ontario	2 230	22 498	16 286	1 137	4 195
Manitoba	202	1 295	1 468	126	413
Saskatchewan	315	1 688	2 000	214	740
Alberta	1 852	2 117	3 847	1 714	7 050
British Columbia	474	4 133	3 333	259	935
Yukon, N.W.T.	12	119	78	5	21
TOTAL CANADA	8 739	102 488	45 910	4 762	19 667

* Expressed as SO_2
** Expressed as NO_2

TABLE 85 UNCONTROLLED EMISSION FACTORS, FUELWOOD COMBUSTION

	Emissions Factors (kg/tonne of wood)				
Source	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Fuelwood combustion	10.0	Neg.	1.5	15.0	60.0

* Expressed as SO_2
** Expressed as NO_2
Neg. - Negligible

3.6 Emissions By Fuel Type

3.6.1 General. The major fuels consumed in stationary combustion sources are coal, heavy fuel oil, light fuel oil and natural gas. Emissions from the combustion of these fuels in residential heating, industrial and commercial units and power generating stations, by fuel type, are given in Tables 87 to 90.

TABLE 86 TOTAL EMISSIONS, FUELWOOD COMBUSTION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	994		149	1 490	5 962
Prince Edward Island	334		50	501	2 005
Nova Scotia	1 843		276	2 764	11 056
New Brunswick	1 843		276	2 764	11 056
Quebec	18 165		2 725	27 247	108 988
Ontario	10 740		1 611	16 110	64 439
Manitoba	1 210		180	1 802	7 208
Saskatchewan	1 409		211	2 114	8 455
Alberta	921		138	1 382	5 528
British Columbia	550		83	825	3 300
Yukon, N.W.T.	334		50	501	2 005
TOTAL CANADA	38 334		5 749	57 500	230 002

* Expressed as SO_2
** Expressed as NO_2

TABLE 87 TOTAL EMISSIONS, COAL USE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia	10 861	59 566	21 775	823	3 517
New Brunswick	4 997	26 974	1 628	50	154
Quebec	8 332	30 443	4 807	320	641
Ontario	19 731	439 726	86 179	1 633	5 087
Manitoba	9 857	6 775	4 889	206	509
Saskatchewan	65 566	38 162	35 845	840	2 786
Alberta	60 806	36 585	22 322	2 536	10 038
British Columbia	653	716	462	46	129
Yukon, N.W.T.					
TOTAL CANADA	180 803	638 947	177 907	6 454	22 861

* Expressed as SO_2
** Expressed as NO_2

TABLE 88 TOTAL EMISSIONS, HEAVY FUEL OIL USE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	2 926	39 871	7 903	96	502
Prince Edward Island	279	3 701	1 159	11	59
Nova Scotia	2 285	80 924	23 699	233	1 143
New Brunswick	3 808	95 663	23 352	230	1 211
Quebec	16 365	221 770	52 344	560	2 942
Ontario	8 535	133 776	36 146	410	2 143
Manitoba	248	3 283	972	10	54
Saskatchewan	189	2 514	746	8	42
Alberta	30	399	118	1	7
British Columbia	2 683	35 405	10 481	112	586
Yukon, N.W.T.	16	205	61		4
TOTAL CANADA	37 364	617 511	156 981	1 671	8 693

* Expressed as SO_2
** Expressed as NO_2

TABLE 89 TOTAL EMISSIONS, LIGHT FUEL OIL USE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	139	4 101	1 192	57	303
Prince Edward Island	45	1 307	377	19	96
Nova Scotia	298	8 634	2 461	122	639
New Brunswick	220	6 319	1 849	89	469
Quebec	1 651	48 455	14 092	684	3 591
Ontario	1 578	27 501	13 915	644	3 403
Manitoba	66	1 165	582	27	143
Saskatchewan	63	1 081	513	25	134
Alberta	36	634	314	15	79
British Columbia	263	4 556	2 173	107	563
Yukon, N.W.T.	28	541	288	13	67
TOTAL CANADA	4 387	104 294	37 756	1 802	9 487

* Expressed as SO_2
** Expressed as NO_2

TABLE 90 TOTAL EMISSIONS, NATURAL GAS USE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec	393	23	5 795	190	712
Ontario	2 742	182	43 516	1 502	5 244
Manitoba	299	17	3 552	189	554
Saskatchewan	458	24	7 666	244	818
Alberta	1 930	109	34 488	936	3 343
British Columbia	616	37	8 225	353	1 147
Yukon, N.W.T.	2		13	1	3
TOTAL CANADA	6 440	392	103 255	3 415	11 821

* Expressed as SO_2

** Expressed as NO_2

4 EMISSIONS FROM TRANSPORTATION SOURCES

4.1 Gasoline-Powered Motor Vehicles

4.1.1 General. Gasoline-powered motor vehicles include all vehicles driven on public roads and using gasoline as fuel. These were classified into seven categories: automobiles, taxis, light-duty trucks, heavy-duty trucks, buses, motorcycles and snowmobiles. Air pollutant emissions from motor vehicles come from three principal sources: exhaust, crankcase blow-by, and evaporation from the fuel tank and carburetor.

4.1.2 Emissions. Emissions of nitrogen oxides, hydrocarbons and carbon monoxide were calculated by the Air Pollution Control Directorate for all categories except motorcycles and snowmobiles (98). These calculations were based upon vehicle registration figures, the age distribution of Canadian vehicles, estimated speed distribution, emission rate degradation factors and estimated vehicle kilometres travelled per year. For particulates and sulphur oxides, emissions were based upon registrations and emission factors obtained from the literature (4), because more detailed studies had not been undertaken by the Directorate for these two contaminants. The emission factors in terms of grams per kilometre were converted to kilograms per vehicle per year on the assumption that automobiles travel 17 220 km per year, light-duty trucks 21 243 km per year, light heavy-duty trucks 22 531 km per year, heavy-duty trucks 27 037 km per year and heavy-duty diesel trucks 72 420 km per year. Registration figures from a Statistics Canada publication were used as base quantities (99).

Emission factors and total emissions for gasoline-powered motor vehicles are given in Tables 91 and 92 respectively.

4.2 Railroads

4.2.1 General. Emissions from railroads are based on the quantities of fuels consumed in the production of energy for locomotion and temperature control. The only fuel considered was diesel oil as the quantity of other fuels used for temperature control was judged insignificant.

4.2.2 Emissions. Railroad fuel consumption quantities were obtained from Statistics Canada (43). Emission factors for the combustion of these fuels were based on data from the U.S. Environmental Protection Agency (4). Sulphur contents of fuels (included in the emission factors) were found in an Energy, Mines and Resources Canada publication (96).

TABLE 91 EMISSION FACTORS, GASOLINE-POWERED MOTOR VEHICLES

	Emission factors (kg/vehicle/yr)				
Vehicle Type	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Automobiles	2.979	1.254	31.351	43.121	361.981
Light-duty trucks	3.648	2.112	36.696	49.368	428.208
Heavy-duty trucks	13.440	5.280	166.488	265.776	3 322.368
Light Heavy-duty trucks	3.648	2.112	73.640	79.940	692.020
Motorcycles[a]	640.0	115.0	768.0	34 112.0	121 600.0
Snowmobiles[a]	1 670.0	51.0	600.0	37 800.0	58 700.0

* Expressed as SO_2
** Expressed as NO_2
[a] Units are g/unit/yr

TABLE 92 TOTAL EMISSIONS, GASOLINE-POWERED MOTOR VEHICLES, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	671	278	7 000	10 969	88 275
Prince Edward Island	223	98	2 507	3 569	31 226
Nova Scotia	1 382	617	15 602	22 178	194 717
New Brunswick	1 114	489	12 382	17 795	153 756
Quebec	9 442	4 006	100 598	147 756	1 227 224
Ontario	14 742	6 411	161 631	230 077	1 975 256
Manitoba	2 173	953	24 096	34 963	300 951
Saskatchewan	2 643	1 229	31 318	43 569	399 162
Alberta	4 800	2 175	55 142	76 940	688 373
British Columbia	5 502	2 467	62 450	87 276	773 828
Yukon	57	26	691	964	8 903
N.W.T.	57	27	672	986	8 851
TOTAL CANADA	42 806	18 776	474 089	677 042	5 850 522

* Expressed as SO_2
** Expressed as NO_2

Emission factors and total emissions for railroads are presented in Tables 93 and 94 respectively.

TABLE 93 EMISSION FACTORS, RAILROADS

Source	Emission factors (kg/10^3 litres)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Diesel oil[a]	3.0	6.8	44.0	11.0	16.0

* Expressed as SO_2
** Expressed as NO_2
a Reference (4) under "Average Locomotive Factors"

TABLE 94 TOTAL EMISSIONS, RAILROADS 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	21	163	309	77	113
Prince Edward Island	9	66	126	32	46
Nova Scotia	208	1 607	3 058	765	1 112
New Brunswick	160	1 234	2 349	587	854
Quebec	771	5 429	11 333	2 833	4 121
Ontario	1 914	9 997	28 126	7 031	10 228
Manitoba	833	5 672	12 235	3 059	4 449
Saskatchewan	481	1 096	7 067	1 767	2 570
Alberta	1 807	4 945	26 562	6 640	9 659
British Columbia	684	2 174	10 048	2 512	3 654
Yukon, N.W.T.	15	85	220	55	80
TOTAL CANADA	6 903	32 468	101 433	25 358	36 886

* Expressed as SO_2
** Expressed as NO_2

4.3 Marine

4.3.1 General. This sector was broken down into three main sections: steam and motor ships which use heavy fuel oil and diesel oil, respectively, and gasoline-powered outboard motors.

4.3.2 Emissions. Ships emit pollutants while underway and while generating auxilary power in port. The number of calls in port, for steam and motor ships, was estimated from the number of ships at Canadian ports for coastwise and international shipping (101, 102). The average time that a ship remains in port (per call) is 2.66 days (103).

The quantity of heavy oil and diesel oil used for steam and motor ships, respectively, in Ontario and Quebec was used to provide an estimate of shipping movement in the Great Lakes, St. Lawrence Seaway region (43). Only inland waterway travel was assumed to produce significant emissions affecting Canadian soil.

Statistics for the number of outboard-powered boats was obtained from Statistics Canada (100). An average of 6.8 kW and an average usage of 50 hours per year were assumed (98). Particulate emissions are assumed to be negligible since outboards have underwater exhausts.

Average emission factors for the combustion of fuels used by marine sources and the sulphur content (included in the emission factors) of these fuels were found in the literature (4, 96).

Emission factors and total emissions for marine sources are shown in Tables 95 and 96 respectively.

4.4 Aircraft

4.4.1 General. Aircraft engines are of two major types: reciprocating (piston) and gas turbine. Both types are further divided into subclasses depending on the size of the aircraft and the most commonly used engine for that class. The types of aircraft included in this section are jets, turboprops, piston-engined planes, helicopters and piston-engined planes at local airports.

4.4.2 Emissions. The calculation of contaminant emissions from aircraft is divided into two categories: Below an altitude of 1100 metres, based upon the number of landing-and-takeoff cycles (one descent and landing from 1100 metres, ground movements, and one takeoff and climb out to 1100 metres) and inflight emissions from aircraft flying above 1100 metres.

Emission factors were calculated using U.S. Environmental Protection Agency data (4) for jets, turboprops, piston-engined planes and helicopters and aircraft specifications obtained from various sources (98, 104, 105, 106).

Statistics on Canadian aircraft movements were obtained from the literature (107).

Emission factors and total emissions attributable to aircraft operations are given in Tables 97 and 98 respectively.

TABLE 95 EMISSION FACTORS, MARINE

	Emission factors					
Source	Particulate matter		Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
DOCKSIDE^{a,d}						
Motor ships	19.9	E. Canada	51.9	60.3	39.8	55.5
- Diesel ships		W. Canada	51.9			
Steam ships	18.1	E. Canada	917.0	241.3	10.9	0.1
- Heavy oil		W. Canada	733.6			
UNDERWAY^{b}						
Motor ships	3.0	Ontario	4.96	31.0	13.0	7.0
- Diesel oil		Quebec	3.66	33.0	12.0	6.0
Steam ships	2.4	Ontario	25.46	6.7	0.08	0.41
- Heavy oil		Quebec	39.02			
OUTBOARD MOTORS^{c}						
- Gasoline			0.37	0.37	63.4	186.4

* Expressed as SO_2
** Expressed as NO_2
a Reference (4) under "Inboard-Powered Vessels"
b Units are g/L
c Units are g/kWh
d Units are kg/call in port

4.5 Off-Road Use of Gasoline

4.5.1 General. Off-road gasoline use was mainly for construction equipment, agricultural equipment and forestry equipment. Approximately 11.5% of the gasoline sold in Canada was not consumed on public roads and highways.

4.5.2 Emissions. Gasoline consumption figures were obtained from the literature (108). Emission factors were taken from the U.S. Environmental Protection Agency (4), and are listed in Table 99. Total emissions attributable to the off-road use of gasoline are listed in Table 100.

TABLE 96 TOTAL EMISSIONS, MARINE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	178	525	556	1 206	2 996
Prince Edward Island	5	16	15	10	14
Nova Scotia	80	508	308	731	1 911
New Brunswick	42	215	152	506	1 362
Quebec	2 527	28 844	13 212	5 896	9 904
Ontario	1 457	16 869	10 879	12 754	30 853
Manitoba	1	10	10	1 432	4 211
Saskatchewan		7	8	1 276	3 754
Alberta		10	11	1 818	5 346
British Columbia	374	1 083	1 177	4 147	11 046
Yukon, N.W.T.	1	3	3	2	3
TOTAL CANADA	4 665	48 090	26 331	29 778	71 400

* Expressed as SO_2
** Expressed as NO_2

4.6 Diesel-Powered Engines

4.6.1 General. In this section, emissions resulting from the combustion of diesel fuel are estimated. It is assumed that all diesel oil is used in internal combustion engines, with none being burned industrially or for heating purposes in the manner that heavy or light fuel oils are (except small quantities of diesel oil used in power generation).

The use of diesel oil for power generation, railway and marine applications is dealt with in Sections 3.1, 4.2 and 4.3.

4.6.2 Emissions. Consumption of diesel oil for construction equipment, agricultural equipment and other diesel engines was obtained from Statistics Canada (43, 108). Emissions from trucks and buses using diesel oil were calculated based on information from the Air Pollution Control Directorate (98). Registration figures from Statistics Canada were used as base quantities (99). Emission factors for the other types of engines were taken from the U.S. Environmental Protection Agency (4).

Emission factors and total emissions for diesel-powered engines are presented in Tables 101 and 102 respectively.

TABLE 97 EMISSION FACTORS, AIRCRAFT

Source	Emissions factors				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
LTO CYCLE[a]					
Jets	0.621	1.061	11.29	11.34	22.60
Turboprops	0.481	0.191	1.32	1.093	2.994
Piston-engined planes	0.024	0.029	0.032	1.152	8.464
Helicopters	0.113	0.163	0.259	0.236	2.585
Local[c]	0.011	0.016	0.023	0.023	6.917
INFLIGHT[b]					
Jets	1.074	2.083	44.020	0.463	0.194
Turboprops	0.009	0.007	0.045	0.093	2.351
Piston-engined planes	0.053	0.042	0.257	0.524	13.324
Helicopters	0.111	0.080	0.259	0.241	2.601
Local	0.020	0.011	0.085	0.299	15.003

* Expressed as SO_2
** Expressed as NO_2
a Units are kg/aircraft LTO cycle
b Units are kg/hour of flight
c Reference (4) under "General Aviation Piston Planes"

4.7 Tire Wear

4.7.1 General. Emissions from tire wear are generated by all vehicles equipped with rubber tires. The abrasive action of the gravel or asphalt roads on the tires removes minute particles from the surface of the tire in contact with the road. The friction between a tire and the surface of a road, especially in some driving conditions, creates sufficient heat to generate traces of hydrocarbon gases.

4.7.2 Emissions. A recent study (109) has revealed that 5% of the total tread wear consisted of airborne particulate matter and 1% hydrocarbon gases. A study done at the University of Cincinnati indicated that the average tire life is 32 000 km and the corresponding loss in weight is about 2.09 kg (110). All highway vehicle types have been

TABLE 98 TOTAL EMISSIONS, AIRCRAFT, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	53	87	1 461	296	1 703
Prince Edward Island	4	5	105	27	297
Nova Scotia	34	61	1 078	213	1 196
New Brunswick	33	48	721	256	4 344
Quebec	259	409	6 781	1 573	14 101
Ontario	357	577	9 627	2 384	26 095
Manitoba	78	122	2 059	454	3 411
Saskatchewan	44	67	1 081	302	3 708
Alberta	308	528	9 149	1 876	11 814
British Columbia	216	327	5 215	1 487	18 046
Yukon	10	14	195	71	1 054
N.W.T.	34	39	534	155	1 518
TOTAL CANADA	1 430	2 284	38 006	9 094	87 287

* Expressed as SO_2
** Expressed as NO_2

TABLE 99 EMISSION FACTORS, OFF-ROAD USE OF GASOLINE

	Emission factors (kg/10^3 litres)				
Source	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Agricultural equipment	0.892	0.636	14.95	16.80	441.5
Heavy-duty construction	0.855	0.632	13.54	28.07	445.6
Industrial engines	0.775	0.636	12.2	27.43	472.0
Average	0.841	0.635	13.56	24.10	453.0

* Expressed as SO_2
** Expressed as NO_2

included and the provincial registration figures were obtained from pertinent information (98, 99). The distance travelled per year per vehicle type was assumed as discussed in Section 4.1.

Emission factors and total emissions are summarized in Tables 103 and 104 respectively.

TABLE 100 TOTAL EMISSIONS, OFF-ROAD USE OF GASOLINE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	17	13	276	488	9 188
Prince Edward Island	9	7	144	256	4 811
Nova Scotia	30	22	478	847	15 944
New Brunswick	48	36	767	1 360	25 585
Quebec	61	46	974	1 726	32 482
Ontario	272	205	4 382	7 765	146 127
Manitoba	235	177	3 784	6 706	126 195
Saskatchewan	461	346	7 417	13 143	247 325
Alberta	560	421	9 021	15 985	300 802
British Columbia	251	189	4 048	7 174	134 995
Yukon	5	4	87	154	2 895
N.W.T.	9	7	150	266	5 009
TOTAL CANADA	1 958	1 473	31 528	55 870	1 051 358

* Expressed as SO_2
** Expressed as NO_2

TABLE 101 EMISSION FACTORS, DIESEL-POWERED ENGINES

	Emission factors (kg/10^3 litres)				
Source	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Heavy-duty vehicles[a]	58.50	126.00	1 030.50	157.05	490.95
Agricultural vehicles	5.50	3.70	40.2	7.30	14.30
Construction vehicles	2.10	3.70	62.80	3.60	11.00
Other Diesel engines	4.00	3.70	56.20	4.50	12.20

* Expressed as SO_2
** Expressed as NO_2
[a] Units are kg/vehicle/year

TABLE 102 TOTAL EMISSIONS, DIESEL-POWERED ENGINES, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	584	764	9 151	942	2 727
Prince Edward Island	155	213	2 207	283	794
Nova Scotia	785	1 189	11 925	1 523	4 456
New Brunswick	756	1 031	11 196	1 325	3 787
Quebec	6 113	7 314	88 377	9 349	26 102
Ontario	7 181	10 230	110 237	13 095	37 608
Manitoba	1 719	2 237	23 309	3 094	8 352
Saskatchewan	4 156	4 744	48 750	7 031	17 902
Alberta	6 031	7 166	81 149	9 872	26 177
British Columbia	2 508	4 161	40 494	5 210	15 661
Yukon	471	487	7 063	588	1 631
N.W.T.	626	640	9 379	770	2 132
TOTAL CANADA	31 085	40 176	443 237	53 082	147 329

* Expressed as SO_2

** Expressed as NO_2

TABLE 103 EMISSION FACTORS, TIRE WEAR

	Emission factors (kg/10^6 km)	
Source	Particulate matter	Hydro-carbons
Tire wear	22.57	4.51

TABLE 104 TOTAL EMISSIONS, TIRE WEAR, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	49			10	
Prince Edward Island	17			3	
Nova Scotia	108			22	
New Brunswick	87			17	
Quebec	730			146	
Ontario	1 155			231	
Manitoba	167			33	
Saskatchewan	206			41	
Alberta	379			76	
British Columbia	434			87	
Yukon	4			1	
N.W.T.	4			1	
TOTAL CANADA	3 340			668	

* Expressed as SO_2

** Expressed as NO_2

5 SOLID WASTE INCINERATION

Solid waste is defined as discarded solid materials, including those resulting from industrial, commercial, agricultural and community activities. Atmospheric emissions, both gaseous and particulate, result from refuse disposal operations that use combustion.

The sources considered in this section are municipal incineration, sewage sludge incineration, industrial and commercial incineration, and wigwam burners.

5.1 Municipal Incineration

5.1.1 Process Description. Municipal incinerators normally have capacities in excess of 50 tonnes per day and are usually equipped with automatic charging mechanisms and temperature controls. The most common type of municipal incinerator consists of a refractory-lined chamber with a grate upon which refuse is burned. It is usually batch-fed. In some newer incinerators, water-walled furnaces are used.

In 1978, approximately 1.10 million tonnes of refuse were disposed of in 13 municipal incinerators. Thirteen pit incinerators were also in operation for disposal of municipal refuse, with a throughput of about 71 000 tonnes of refuse. By the end of 1978 only 10 municipal incinerators remained in operation.

5.1.2 Emission Sources. Large quantities of uncombusted particulates and carbon monoxide are emitted after charging of batch-fed units. In continuously-fed units, furnace particulate emissions depend mainly upon the type of grate used.

5.1.3 Controls. Pit incinerators were largely uncontrolled and particulate control on other municipal incinerators varied widely. Water sprays, with an average control efficiency of 45%, settling chambers or, in newer plants, electrostatic precipitators were the most common types of air pollution control equipment used.

5.1.4 Emissions. Information on control equipment and quantities of municipal refuse burned in different incinerators across Canada was obtained from several sources (3, 10, 45, 111). Emission factors were taken from a U.S. Environmental Protection Agency publication (4) for all contaminants, except for particulates where emission factors were developed from previous data (3). Pit incinerator information was available from the same sources (3, 4, 10, 45).

Emission factors and total emissions for municipal incineration are presented in Tables 105 and 106 respectively.

TABLE 105 UNCONTROLLED EMISSION FACTORS, MUNICIPAL INCINERATION

	Emission factors (kg/tonne charged material)				
Source	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Municipal incinerators	15.0	1.25	1.50	0.75	17.50
Pit incinerators					
- open pit	4.98	1.25	0.13	0.11	8.57
- closed pit	6.20	1.25	0.13	0.11	8.57

* Expressed as SO_2
** Expressed as NO_2

TABLE 106 TOTAL EMISSIONS, MUNICIPAL INCINERATION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec	2 443	735	834	420	9 995
Ontario	635	469	543	273	6 430
Manitoba	1 687	121	142	71	1 669
Saskatchewan	124	21	18	9	251
Alberta					
British Columbia	87	20	5	4	157
Yukon, N.W.T.					
TOTAL CANADA	4 976	1 366	1 542	777	18 502

* Expressed as SO_2
** Expressed as NO_2

5.2 Industrial and Commercial Incineration

5.2.1 Process Description. Industrial and commercial incinerators are generally capable of burning from 25 to 1800 kg of refuse per hour. Of these intermediate-size units the most common are of multiple chamber design. Gases from the primary chamber flow to a small secondary mixing chamber where more air is admitted and therefore more complete oxidation occurs.

Controlled air incinerators operate on a controlled combustion principle where refuse is burned in the absence of sufficient oxygen to complete combustion in the main chamber. This process generates a highly combustible gas mixture that is then burned with excess air in a secondary chamber, resulting in efficient combustion.

In 1978, approximately 600 000 tonnes of refuse were burned in industrial and commercial incinerators.

5.2.2 **Emission Sources.** Carbon monoxide and particulate matter are the major contaminants emitted from incineration of refuse in industrial or commercial incinerators. Emissions of the other contaminants also occur depending upon the type of incinerator being used.

5.2.3 **Controls.** Most of the industrial and commercial incinerators were without control; however, multiple chamber units usually had afterburners installed as part of the process to improve combustion.

5.2.4 **Emissions.** The amount of solid waste incinerated in industrial and commercial units was estimated using information from the literature (112). Emission factors were obtained from an Environment Canada publication (113). Emission factors for multiple chamber incinerators were applied to 75% of the total refuse burned, since 25% of the incinerators used were considered to be the controlled-air type.

Emission factors and total emissions are listed in Tables 107 and 108 respectively.

TABLE 107 UNCONTROLLED EMISSION FACTORS, INDUSTRIAL AND COMMERCIAL INCINERATION

	Emission factors (kg/tonne charged material)				
Incinerator type	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Multiple chamber	2.2	1.25	1.1	0.5	1.8
Controlled air	0.9	0.75	1.6	Neg.	Neg.

* Expressed as SO_2
** Expressed as NO_2
Neg. - negligible

TABLE 108 TOTAL EMISSIONS, INDUSTRIAL AND COMMERCIAL INCINERATION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	18	11	12	4	13
Prince Edward Island	5	2	3	1	3
Nova Scotia	37	23	24	7	27
New Brunswick	28	17	19	6	21
Quebec	286	172	187	57	207
Ontario	448	269	293	90	322
Manitoba	49	29	31	10	35
Saskatchewan	36	22	24	7	26
Alberta	82	49	53	16	59
British Columbia	119	71	77	24	86
Yukon, N.W.T.	2	1	2		2
TOTAL CANADA	1 110	666	725	222	801

* Expressed as SO_2
** Expressed as NO_2

5.3 Sewage Sludge Incineration

5.3.1 Process Description. Sewage sludge is a by-product of sewage treatment processes. Although a number of alternatives exist for the treatment and disposal of sludge, incineration was the disposal method used in six municipalities in Canada in 1978. Approximately 62 000 tonnes of sewage sludge were incinerated.

In the incineration process, sludge is freed of moisture prior to combustion and elevated to the ignition point. Air and auxiliary fuel may be required to support and maintain combustion. The residual inorganic ash is then cooled and disposed of. Multiple-hearth furnaces were used at three incineration facilities, while the other three facilities employed the fluidized-bed type.

5.3.2 Emission Sources. A major particulate emission source is the furnace itself. Odour can be a problem in multiple-hearth systems as unburned volatiles are given off in the upper drying hearth. Sulphur oxides and nitrogen oxides are also emitted in significant amounts, with hydrocarbons also being emitted in small quantities.

5.3.3 Emissions. Information on the quantities of sludge incinerated and on controls was obtained from various sources (3, 10). Uncontrolled emission factors for multiple hearth furnaces were calculated from actual source testing data at one plant and applied to the others.

Emission factors for fluidized-bed units were obtained from the U.S. Environmental Protection Agency (4). These factors were used where actual emission data were not available. Emission factors and total emissions for sewage sludge incineration are presented in Tables 109 and 110 respectively.

TABLE 109 UNCONTROLLED EMISSION FACTORS, SEWAGE SLUDGE INCINERATION

Incinerator type	Emission factors (kg/tonne dry sludge) Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Multiple-hearth furnace	11.5	10	3	0.75	Neg.
Fluidized-bed	50	0.5	3	0.75	Neg.

* Expressed as SO_2
** Expressed as NO_2
Neg. - negligible

5.4 Wigwam Burners

5.4.1 General. The wigwam burner, used for disposal of sawdust, is a major source of air pollution associated with the lumber and plywood industry.

5.4.2 Emissions. An estimate of the amount of waste wood burned, based on production of softwood and hardwood lumber, was used to calculate an estimate of wood waste relative to production (45, 114, 115). Emissions were calculated using emission factors from the U.S. Environmental Protection Agency (4).

Emission factors and total emissions for solid waste disposal by wigwam burners are given in Tables 111 and 112 respectively.

TABLE 110 TOTAL EMISSIONS, SEWAGE SLUDGE INCINERATION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland					
Prince Edward Island					
Nova Scotia					
New Brunswick					
Quebec					
Ontario	107	581	174	44	Neg.
Manitoba					
Saskatchewan	4	1	5	1	Neg.
Alberta					
British Columbia	22	3	5	2	Neg.
Yukon, N.W.T.					
TOTAL CANADA	133	585	184	47	Neg.

* Expressed as SO_2
** Expressed as NO_2
Neg. - negligible

TABLE 111 UNCONTROLLED EMISSION FACTORS, WIGWAM BURNERS

	Emission factors (kg/tonne)				
Source	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Wigwam burners	5.5	0.05	0.5	5.5	65.0

* Expressed as SO_2
** Expressed as NO_2

TABLE 112 TOTAL EMISSIONS, WIGWAM BURNERS, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	76	1	7	76	900
Prince Edward Island	25		2	25	300
Nova Scotia	301	3	27	301	3 560
New Brunswick	629	6	57	629	7 430
Quebec	5 091	46	463	5 091	60 170
Ontario	2 574	23	234	2 574	30 420
Manitoba	168	2	15	168	1 986
Saskatchewan	328	3	30	328	3 881
Alberta	1 096	10	100	1 096	12 957
British Columbia	19 883	181	1 808	19 883	234 980
Yukon, N.W.T.	9		1	9	111
TOTAL CANADA	30 180	275	2 744	30 180	356 695

* Expressed as SO_2

** Expressed as NO_2

6 EMISSIONS

6.1 Fertilizer Application

6.1.1 Process Description. The use of fertilizer involves both handling the product, in bags or bulk, and spreading it on the field.

6.1.2 Emission Sources. The main emission source is the spreading operation; many fine particulates including those produced by abrasion enter the atmosphere during this operation. The activity of spreading is more vigorous than that of bulk material handling encountered in the fertilizer manufacturing industry.

6.1.3 Controls. A control efficiency of 50% was assumed on handling operations. Spreading was considered to be uncontrolled.

6.1.4 Emissions. About 90% of the total particulate emissions from fertilizer application in Canada was due to field application of fertilizer. Consumption of fertilizer for agricultural application in Canada in 1978, emission factors, and control levels for each operation were obtained from various sources (116, 63).

Emission factors and total emissions for fertilizer application are presented in Tables 113 and 114 respectively.

TABLE 113 UNCONTROLLED EMISSION FACTORS, FERTILIZER APPLICATION

Operation	Emission factors for particulate matter (kg/tonne fertilizer)
Bulk handling, loading	0.25
Spreading	2.0

6.2 Pesticide Manufacturing and Application

6.2.1 General. Most of the pesticides imported into Canada are technical grade pesticides which are subsequently formulated for direct application. Formulated products can be in solid form with varying particle sizes, in liquid or gaseous form. The methods of application are numerous, from hand-held sprays to aerial spraying.

6.2.2 Emissions. There are four main sources of emissions: manufacturing, formulation, application, and post-application. Good emission controls are used at manufacturing and formulating plants; however, no control is available for the latter two

TABLE 114 TOTAL EMISSIONS, FERTILIZER APPLICATION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	13				
Prince Edward Island	119				
Nova Scotia	79				
New Brunswick	129				
Quebec	869				
Ontario	1 994				
Manitoba	1 026				
Saskatchewan	973				
Alberta	1 567				
British Columbia	141				
Yukon, N.W.T.					
TOTAL CANADA	6 910				

* Expressed as SO_2

** Expressed as NO_2

sources. Emissions from these sources vary considerably and are dependent on the physical and chemical characteristics of the pesticide, and on the method of application as well as on meteorological conditions.

Particulate emission factors were obtained from published literature (117). The quantity of technical grade pesticide and the amount of pesticide in formulated products was estimated using information from various sources (118, 119, 128).

Tables 115 and 116 summarize the emission factors and total emissions for pesticide manufacturing and application respectively.

TABLE 115 EMISSION FACTORS, PESTICIDE MANUFACTURING AND APPLICATION

Source	Emission factors for particulate matter (kg/tonne of pesticide)
Application	100
Post Application	150

TABLE 116 TOTAL EMISSIONS, PESTICIDE MANUFACTURING AND APPLICATION, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	3				
Prince Edward Island	195				
Nova Scotia	72				
New Brunswick	152				
Quebec	625				
Ontario	3 804				
Manitoba	5 140				
Saskatchewan	9 797				
Alberta	6 687				
British Columbia	241				
Yukon, N.W.T.					
TOTAL CANADA	26 716				

* Expressed as SO_2

** Expressed as NO_2

6.3 Gasoline and Diesel Marketing

6.3.1 Process Description. The handling of gasoline and diesel fuels from the refinery to the consumer results in the loss of hydrocarbons to the atmosphere by evaporation.

6.3.2 Emission Sources. Emissions from gasoline-marketing facilities involve the losses caused by product transfer activities (loading-unloading) and the losses associated with storage tanks located at terminal sites (excluding storage within refineries).

Hydrocarbons are the only contaminants considered for these sources.

6.3.3 Emissions. Emission factors were obtained from the Air Pollution Control Directorate (39) and a U.S. Environmental Protection Agency document (4). It was assumed that all gasoline passes through tank trucks at one time or another and that each province transported only a percentage of total distribution by ship or barge. Emission factors for diesel marketing were assumed to be 10% of those for gasoline. Gross sales of gasoline and diesel oil were taken from the literature (108).

Emission factors and total emissions are presented in Tables 117 and 118 respectively.

TABLE 117 UNCONTROLLED EMISSION FACTORS, GASOLINE AND DIESEL MARKETING

Source	Emission factors for hydrocarbons (kg/10^3 litres)
LOADING AND UNLOADING ACTIVITIES	
Refinery Storage Transfer	
Maritimes	0.963
Quebec & Ontario	0.661
Prairies	0.585
British Columbia	0.698
Territories	0.585
TANKCAR/TRUCK TO GAS STATION, UNDERGROUND STORAGE	
Station Storage Transfer	0.876
Transfer to Cars	0.125
Filling Vehicle Tanks	1.375
Station Spillage	0.084
VAPOUR LOSSES FROM STORAGE TANKS AT TERMINAL SITES (excluding Terminal Vapour Loss)	3.300

TABLE 118 TOTAL EMISSIONS, GASOLINE AND DIESEL MARKETING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland				4 231	
Prince Edward Island				1 315	
Nova Scotia				8 250	
New Brunswick				7 621	
Quebec				57 203	
Ontario				84 123	
Manitoba				4 569	
Saskatchewan				12 954	
Alberta				26 681	
British Columbia				26 805	
Yukon				407	
N.W.T.				291	
TOTAL CANADA				234 450	

* Expressed as SO_2

** Expressed as NO_2

6.4 Dry Cleaning

6.4.1 Process Description. Textiles may be cleaned by treating them either with chlorinated synthetic solvents or petroleum solvents.

Dry cleaning operations involve agitating the clothing in a solvent bath, rinsing with clean solvent and drying with warm air.

6.4.2 Emission Sources. Hydrocarbons are the only contaminants considered in these operations and result from the evaporation of organic solvents.

6.4.3 Emissions. An internal document was used to compute total Canadian emissions while solvent consumption was obtained from a reliable survey (32, 56). In the absence of information on the quantities of solvents consumed for dry cleaning purposes in each province, provincial emissions were based on population.

Installations using perchloroethylene or fluorocarbon solvents are well controlled by methods such as condensation and carbon adsorption or refrigerated condensation. On the other hand, petroleum solvents are essentially uncontrolled.

Total emissions from dry cleaning are presented in Table 119.

TABLE 119 TOTAL EMISSIONS, DRY CLEANING INDUSTRY, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydrocarbons	Carbon monoxide
Newfoundland				385	
Prince Edward Island				83	
Nova Scotia				569	
New Brunswick				470	
Quebec				4 222	
Ontario				5 707	
Manitoba				694	
Saskatchewan				642	
Alberta				1 339	
British Columbia				1 721	
Yukon				15	
N.W.T.				29	
TOTAL CANADA				15 876	

* Expressed as SO_2
** Expressed as NO_2

6.5 Application of Surface Coatings

6.5.1 Process Description. Surface-coating operations primarily involve the application of paint, lacquer, varnish or paint primer for decorative or protective purposes. The major Canadian surface coating applicators include the automobile, strip, sheet and coil coating and household appliance manufacturing industries.

6.5.2 Emission Sources. Hydrocarbons are the only contaminants considered for this operation and emissions arise from the evaporation of solvents as the coating dries.

6.5.3 Emissions. Solvent consumption (including imports less exports) was obtained from the literature (10, 123). It was assumed that all solvents are lost or emitted. An internal report (32) provided national emissions for both trade and industrial sales. Emissions were calculated on a provincial basis based on population for trade sales (122) and on industrial labour force for industrial sales (124).

Total emissions for application of surface coatings are presented in Table 120.

TABLE 120 TOTAL EMISSIONS, APPLICATION OF SURFACE COATINGS, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydrocarbons	Carbon monoxide
Newfoundland				1 936	
Prince Edward Island				437	
Nova Scotia				3 016	
New Brunswick				2 443	
Quebec				33 721	
Ontario				58 097	
Manitoba				3 871	
Saskatchewan				3 473	
Alberta				6 797	
British Columbia				14 410	
Yukon, N.W.T.				228	
TOTAL CANADA				128 429	

* Expressed as SO_2
** Expressed as NO_2

6.6 Structural Fires

6.6.1 General. Canada had approximately 75 000 structural fires in 1978.

6.6.2 Emission Sources. Significant amounts of carbon monoxide, particulate matter and hydrocarbons are emitted from building fires. Emissions of nitrogen oxides are considered negligible.

6.6.3 Emissions. Information on the number of fires in each province was obtained from a Public Works Canada publication (125). Emission factors used were those from a previous inventory based on one million fires (1).

Emission factors and total emissions attributable to structural fires in Canada are presented in Tables 121 to 122 respectively.

TABLE 121 UNCONTROLLED EMISSION FACTORS, STRUCTURAL FIRES

	Emission factors (tonnes/fire)		
Source	Particulate matter	Hydro-carbons	Carbon monoxide
Structural fires	0.09	0.09	0.18

TABLE 122 TOTAL EMISSIONS, STRUCTURAL FIRES, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	66			66	132
Prince Edward Island	54			54	107
Nova Scotia	205			205	409
New Brunswick	127			127	254
Quebec	1 745			1 745	3 490
Ontario	2 267			2 267	4 534
Manitoba	510			510	1 021
Saskatchewan	239			239	477
Alberta	867			867	1 733
British Columbia	670			670	1 339
Yukon	13			13	27
N.W.T.	14			14	29
TOTAL CANADA	6 777			6 777	13 552

* Expressed as SO_2

** Expressed as NO_2

6.7 Cigarette Smoking

6.7.1 General. Cigarette smoking is the burning of tobacco at low temperatures. Significant amounts of carbon monoxide are generated since the combustion parameters are uncontrolled. Emissions from a cigarette are relatively very low and are measured in milligrams; however, the consumption is high.

6.7.2 Emissions. Particulates and carbon monoxide are emitted. Emission factors for cigarette smoking were taken from a published document prepared by the U.S. Department of Health, Education and Welfare (127). Cigarette consumption was obtained from a Statistics Canada publication (126) and prorated based on population to obtain provincial figures.

Emission factors and total emissions for cigarette smoking are presented in Tables 123 and 124 respectively.

TABLE 123 EMISSION FACTORS, CIGARETTE SMOKING

	Emission factors (mg/cigarette)	
Source	Particulate matter	Carbon Monoxide
Cigarette Smoking	70	28

6.8 General Solvent Use

6.8.1 General. The use of solvents involves both industrial and domestic applications. Industrial solvent degreasing is the single largest component of this sector.

6.8.2 Process Description. Solvent degreasing is a process that exposes a material to an organic solvent, thereby physically removing any grease, wax or dirt from the metal, glass, plastic or fabric material. Dependant on the type of material being degreased, various different methods may be employed.

General domestic solvents are found in products used regularly around the home, from personal care items and lotions, to cleansers and polishes.

6.8.3 Emission Sources. The sources of emissions of volatile organics are the degreasing operations where solvent evaporation occurs. Sources are numerous while the extent of emissions are dependant upon the individual processes.

TABLE 124 TOTAL EMISSIONS, CIGARETTE SMOKING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	105				42
Prince Edward Island	22				9
Nova Scotia	155				62
New Brunswick	127				51
Quebec	1 169				468
Ontario	1 550				620
Manitoba	192				77
Saskatchewan	173				69
Alberta	345				138
British Columbia	463				185
Yukon	4				2
N.W.T.	8				3
TOTAL CANADA	4 313				1 726

* Expressed as SO_2
** Expressed as NO_2

In domestic use, the volatile organic emissions are due mainly to the solvents present in the products. Due to the low boiling point of the common solvents used, organics are released to the atmosphere as soon as the product is removed from the container.

6.8.4 Controls. Various large processes do control vapor releases with some form of vapour trapping and recovery technique. However there are numerous small installations with no control hence the emissions were considered to be uncontrolled, for both industrial and domestic usages.

6.8.5 Emissions. Based on Hooghen et al. (1979) which were referenced in an unpublished study (133), a prorated emission factor for all degreasing operations of 2.25 kg/person on a per capita basis was obtained. A population based emission factor of 0.9 kg/person was also given in the same study for domestic use. A resultant emission factor of 3.15 kg/person was therefore obtained for total general solvent used (133).

Total emissions from general solvents use are presented in Table 125.

TABLE 125 TOTAL EMISSIONS, GENERAL SOLVENTS USE, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland				1 757	
Prince Edward Island				372	
Nova Scotia				2 610	
New Brunswick				2 133	
Quebec				19 639	
Ontario				26 033	
Manitoba				3 218	
Saskatchewan				2 902	
Alberta				5 790	
British Columbia				7 770	
Yukon				69	
N.W.T.				134	
TOTAL CANADA				72 427	

* Expressed as SO_2
** Expressed as NO_2

6.9 Landfill Sites

6.9.1 Process Description. One method of waste disposal is the burial of solid wastes in the ground using heavy equipment. The anaerobic decomposition of organic waste results in the production of several organic gases; methane being the most common.

6.9.2 Controls. Control technology for controlling gaseous emissions from land fills is effective but implementation is minimal. Prevention of decomposition by prior incineration and treatment reduces emissions, however it is costly. Capping of landfill sites is effective but only as a temporary measure. The best method is to control the gas with collection systems and hydraulic pressure which will also affect the production rate of the gas.

6.9.3 Emissions. Emissions of organic gases from landfill sites were estimated using information obtained from unpublished material (133).

Total emissions from landfill sites are present in Table 126.

6.10 Forest Fires

6.10.1 General. Approximately 281 100 hectares of forest in Canada were consumed by fire in 1978.

TABLE 126 TOTAL EMISSIONS, LANDFILL SITES, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland				375	
Prince Edward Island				80	
Nova Scotia				554	
New Brunswick				457	
Quebec				4 105	
Ontario				5 549	
Manitoba				675	
Saskatchewan				624	
Alberta				1 301	
British Columbia				1 674	
Yukon				15	
N.W.T.				28	
TOTAL CANADA				15 437	

* Expressed as SO_2
** Expressed as NO_2

6.10.2 Emission Sources. Forest fires are a major natural source of air contaminants and produce large quantities of carbon monoxide, hydrocarbons and particulate matter. Nitrogen oxides are also emitted, but at lower rates.

6.10.3 Emissions. Information on the number of hectares burned in each province was obtained from internal sources (120). This was converted to tonnes of dry wood using a conversion factor of 22 tonnes/ha (120). Emission factors were obtained from published data (4, 121).

Emission factors and total emissions for forest fires are given in Tables 127 and 128 respectively.

6.11 Slash Burning

6.11.1 General. Slash is burned to reduce the hazard of forest fires, for insect control, and for the provision of favourable growing conditions for seedlings.

6.11.2 Emission Sources. Slash burning is a major source of air pollution associated with the logging industry. In comparison to refuse incineration, the emission of particulates, carbon monoxide, and hydrocarbons in slash burning is greater because of the relatively low temperatures associated with this operation. Likewise, nitrogen oxide

TABLE 127 UNCONTROLLED EMISSION FACTORS, FOREST FIRES

Source	Emission factors (kg/tonne) Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Forest fires	75.0	Neg.	2.0	12.0	80.0

* Expressed as SO_2
** Expressed as NO_2
Neg.- negligible

TABLE 128 TOTAL EMISSIONS, FOREST FIRES, 1978

	Emissions (tonnes) Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	7 722		206	1 236	8 237
Prince Edward Island	333		9	53	356
Nova Scotia	1 219		33	195	1 301
New Brunswick	4 351		116	696	4 641
Quebec	6 059		162	969	6 463
Ontario	12 415		331	1 986	13 242
Manitoba	40 607		1 083	6 497	43 314
Saskatchewan	152 714		4 072	24 434	162 895
Alberta	12 855		343	2 057	13 712
British Columbia	82 637		2 204	13 222	88 146
Yukon	12 202		325	1 952	13 015
N.W.T.	130 395		3 477	20 863	139 088
TOTAL CANADA	463 509		12 361	74 160	494 410

* Expressed as SO_2
** Expressed as NO_2

emissions are suppressed. Sulphur oxide emissions are a direct function of the sulphur content of the refuse burned and are considered negligible.

6.11.3 Emissions. Information on the quantity of slash burned in Canada in 1978 was calculated based on primary forest production (115) and a conversion factor of 1 tonne slash per 63 052 m^3 forest production. Emission factors were obtained from a U.S. Environmental Protection Agency publication (4).

Emission factors and total emissions from slash burning are listed in Tables 129 and 130 respectively.

TABLE 129 UNCONTROLLED EMISSION FACTORS, SLASH BURNING

	Emission factors (kg/tonne)			
Source	Particulate matter	Nitrogen oxides*	Hydro-carbons	Carbon monoxide
Slash burning[a]	8.5	1.0	2.0	25.0

* Expressed as NO_2

[a] Reference (4) under "Open Burning - Wood Waste"

TABLE 130 TOTAL EMISSIONS, SLASH BURNING, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Newfoundland	1 226		144	289	3 607
Prince Edward Island	85		10	20	251
Nova Scotia	2 228		262	524	6 553
New Brunswick	4 560		537	1 073	13 413
Quebec	18 264		2 149	4 298	53 719
Ontario	10 819		1 273	2 546	31 821
Manitoba	966		114	227	2 842
Saskatchewan	1 534		181	361	4 513
Alberta	3 494		411	822	10 276
British Columbia	40 284		4 739	9 478	118 481
Yukon, N.W.T.	90		11	21	263
TOTAL CANADA	83 550		9 831	19 659	245 739

* Expressed as SO_2

** Expressed as NO_2

REFERENCES

1. Environment Canada, Air Pollution Control Directorate, A Nationwide Inventory of Emissions of Air Contaminants 1976, Report EPS 3-AP-80-1 (January 1981).

2. Cajka, C.J., Iron Ore - 1979, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

3. Environment Canada, Air Pollution Control Directorate, Pollution Data Analysis Division (unpublished information).

4. U.S. Environmental Protection Agency, Compilation of Air Pollutant Emission Factors, Publication No. AP-42 (1977).

5. U.S. Environmental Protection Agency, Particulate Pollutant System Study, Vol. III - Handbook of Emission Properties (1971).

6. Environment Canada, Air Pollution Control Directorate, Mining, and Mineral Processes Division (unpublished information).

7. Ontario Ministry of the Environment (unpublished information).

8. Schultz International Ltd., Pacific and Yukon Region Air Contaminants Inventory 1978, Prepared for Environment Canada, July, 1981.

9. Pearson, D., Aluminum - 1979, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

10. Environment Canada, Air Pollution Control Directorate (Regional Offices unpublished information).

11. Cranstone, D.A., Copper - 1979, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

12. Gauvin, M.J., Nickel - 1979, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

13. Hogan, J.J., and Gauvin, M.J., Lead - 1979, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

14. Brown, D.H., Zinc - 1979, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

15. Statistics Canada, Iron and Steel Mills, Publication No. 41-203 (1978).

16. Statistics Canada, Abrasives Manufacturers, Publication No. 44-202 (1978).

17. Law-West, D.G., Silicon, Ferrosilicon, Silicon Carbide and Fused Alumina - 1979, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

18. Personal communication with Energy, Mines and Resources personnel.

19. Industry, Trade and Commerce, The Canadian Ferrous Foundry Industry; Report of the 1976 National Survey, 1976.

20. Mineral Resources Branch, Metallurgical Works in Canada, Primary Iron and Steel - January 1979, Operators List 2. Department of Energy, Mines and Resources, Ottawa.

21. Vagt, G.O., Asbestos - 1979, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

22. Gagan, E.W., Air Pollution Emissions and Control Technology, Asbestos Mining and Milling Industry, Environment Canada, Report EPS 3-AP-76-6 (February 1977).

23. U.S. Environmental Protection Agency, National Emissions Inventory of Sources and Emissions of Magnesium, EPA 450/3-74-010 (May 1973).

24. Department of Energy, Mines and Resources (personal communication).

25. Department of Industry, Trade and Commerce (personal communication).

26. Statistics Canada, Metal Mines, Publication No. 26-223, (1978).

27. Statistics Canada, Non-metal Mines, Publication No. 26-224, (1978).

28. Statistics Canada, Quarries and Sand Pits, Publication No. 26-225, (1978).

29. Engineering & Mining Journal, International Directory of Mining and Mineral Processing Operations, 1979.

30. U.S. Environmental Protection Agency, Metals Mining and Milling Process Profiles with Environmental Aspects, EPA-600/2-76-167 (1976).

31. Barry, G.S., Salt - 1978, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

32. Environment Canada, Air Pollution Control Directorate, Chemical Process Sources Division (unpublished information).

33. Stonehouse, D.H., Lime - 1978, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

34. Department of Energy, Mines and Resources, Ottawa (unpublished information).

35. Stonehouse, D.H., Gypsum and Anhydrite - 1979, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

36. Pearse, G.H.K., Nepheline Syenite and Feldspar - 1978, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

37. Boyd, B.W., Nepheline Syenite and Feldspar - 1979, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

38. Aylsworth, J.A., Weyland, H.J., Coal and Coke - 1978, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

39. Environment Canada, Air Pollution Control Directorate, Fuels Division (unpublished information).

40. Kootenay Air and Water Quality Study - Phase II, Air Quality in the Elkford-Sparwood-Fernie Region, Ministry of the Environment, Province of British Columbia (April 1978).

41. Energy Sector, Coal Mines in Canada, January 1979, Operators List 4, Department of Energy, Mines and Resources, Ottawa.

42. The Asphalt Handbook, Manual 34, The Asphalt Institute (1965).

43. Statistics Canada, Quarterly Report on Energy Supply - Demand in Canada, Publication No. 57-003, IV Quarter, 1978.

44. Statistics Canada, Refined Petroleum Products, Publication No. 45-208 (1977).

45. Environment Canada, Air Pollution Control Directorate, Combustion Sources Division (unpublished information).

46. Alberta Environment (personal communication).

47. Ecolog, Metro Toronto Tests Scrap-Rubber Paving, July 4, 1977.

48. Statistics Canada, Stone Quarries, Publication No. 26-217 (1978).

49. Stonehouse, D.H., Stone - 1978, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

50. U.S. Environmental Protection Agency, Source Assessment: Crushed Limestone, State of the Art, EPA-600/2-78-004 (1978).

51. Stonehouse, D.J., Sand and Gravel - 1978, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

52. U.S. Environmental Protection Agency, Standards Support and Environmental Impact Statement Volume 1: Proposed Standards of Performance for Kraft Pulp Mills (September 1976).

53. Industrial Sulphur Emissions for Alberta, 1974-1978, Alberta Environment Research Secretariat (April 1979).

54. Benjamin, R.M., Air Pollution Emissions and Control Technology: Wood Pulping Industry, Environment Canada, Report EPS 3-AP-77-6 (March 1979).

55. Air Quality Management at Syncrude Canada Ltd, Environmental Affairs, Syncrude Canada.

56. C.P.I. Product Profiles, Corpus Information Services Ltd.

57. Barry, G.S., Potash - 1978, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

58. Barry, G.S., Potash - 1979, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

59. Barry, G.S., Phosphate - 1978, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

60. The Canadian Fertilizer Market, J.W. Brown and H.D. Blenkhorn, Presented to 25th Annual Meeting of Fertilizer Industry Round Table (November 1975).

61. Statistics Canada, Fertilizer Trade, Publication No. 46-207 (1977).

62. Statistics Canada, Specified Chemicals, Publication No. 46-002, (December 1978).

63. Canadian Fertilizer Institute, National Retail Sales Report, June, 1979.

64. Statistics Canada, Manufacturers of Industrial Chemicals, Publication No. 46-219 (1978).

65. Canadian Chemical Processing (April 1976).

66. Statistics Canada, Clay Products Manufacturers - From Domestic Clays, Publication No. 44-215 (1978).

67. Statistics Canada, Refractories Manufacturers, Publication No. 44-214 (1978).

68. Statistics Canada, Clay Products Manufacturers - From Imported Clays, Publication No. 44-216 (1978).

69. Mineral Resources Branch, Ceramic Plants in Canada, January 1975, Operators List 6, Department of Energy, Mines and Resources, Ottawa.

70. Department of Energy, Mines and Resources, Fuels Research Centre (unpublished information).

71. U.S. Environmental Protection Agency, Revision of Evaporative Emission Factors, EPA-450/3-76-039 (August 1976).

72. Canadian Petroleum Refineries Atmospheric Emissions Survey 1978, Petroleum Association for Conservation of the Canadian Environment.

73. U.S. Environmental Protection Agency, Summary Report on Emissions from the Glass Manufacturing Industry, EPS 600-2-79-101.

74. U.S. Environmental Protection Agency, Source Assessment: Glass and Container Manufacturing Plants, EPA-600/2-76-269 (1976).

75. U.S. Environmental Protection Agency, Source Assessment: Pressed and Blown Glass Manufacturing Plants, EPA-600/2-77-005 (1977).

76. U.S. Environmental Protection Agency, Source Assessment: Flat Glass Manufacturing Plants, EPA-600/2-76-032b (1976).

77. Statistics Canada, Glass and Glass Products Manufacturers, Publication No. 44-207 (1978).

78. Saskatchewan Department of the Environment (unpublished information).

79. Statistics Canada, Concrete Products Manufacturers, Publication No. 44-205 (1978).

80. Statistics Canada, Concrete Products, Publication No. 44-002 (December 1978).

81. Mineral Resources Branch, Natural Gas Processing Plants in Canada, January 1979, Operators List 7, Department of Energy, Mines and Resources, Ottawa.

82. Energy Resource Conservation Board, Alberta Oil and Gas Industry Annual Statistics 1979.

83. Thomas, R.L., Natural Gas - 1978, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

84. Nitrous Oxides Emissions for Alberta, Research Management Division, Alberta Environment, December 1980.

85. Stonehouse, D.H., Cement - 1979, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

86. Pearse, G.H.K., Silica - 1979, Mineral Review Preprint, Department of Energy, Mines and Resources, Ottawa.

87. Statistics Canada, Grain Trade in Canada, Publication No. 22-201 (1978-79).

88. Canadian Grain Commission, Grain Elevators in Canada-Crop Year 1975-76.

89. Environment Canada, Atmospheric Emissions and Control Technology: Canadian Grain Handling Industry, Chemical Process Sources Division, unpublished report.

90. Milling and Baking News (1978).

91. U.S. National Technical Information Service, Emission Factor Development for the Feed and Grain Industry (October 1974).

92. Statistics Canada, Electric Power Statistics, Volume II, Publication No. 57-202 (1978).

93. Ontario Hydro, Estimates of Atmospheric Emissions from Ontario Hydro Fossil-Fuel-Fired Thermal Generating Stations, 1978, CTS-07120-1.

94. Nova Scotia Power Corporation (Personal communication).

95. New Brunswick Power Commission (Personal communication).

96. Energy Policy Sector, Petroleum Refineries in Canada, January 1978, Operators List 5, Department of Energy, Mines and Resources, Ottawa.

97. Statistics Canada, Logging, Publication No. 25-201 (1978).

98. Environment Canada, Air Pollution Control Directorate, Mobile Sources Division (unpublished information).

99. Statistics Canada, Road Motor Vehicles - Registrations, Publication No. 53-219 (1978).

100. Statistics Canada, Household Facilities and Equipment, Publication No. 64-202 (1978).

101. Statistics Canada, Shipping Report, Part II, Publication No. 54-203 (1978).

102. Statistics Canada, Shipping Report, Part III, Publication No. 54-204 (1978).

103. National Harbours Board (Mr. J.M. Gaudreau).

104. Statistics Canada, Air Carrier Operations in Canada, 1978 IV Quarter, publication No. 51-002.

105. Air Canada, (Personal communication).

106. Transport Canada (Personal communication).

107. Transport Canada, Aircraft Movement Statistics Annual Report - 1978, Aviation Statistics Centre.

108. Statistics Canada, Road Motor Vehicles: Fuel Sales, Publication No. 53-218 (1978).

109. Cadle, S.H. and Williams, R.L., Gas and Particulate Emissions from Automobile Tires and Field Studies, Journal of the Air Pollution Control Association, pp. 502-507 (May 1978).

110. Subramani, J.P., Particulate Air Pollution from Automobile Tire Tread Wear, PhD. Thesis, University of Cincinnati (1972).

111. McCrae, A.M., An Evaluation of a Controlled Air Municipal Incinerator, Environment Canada, Report EPS-4-EC-76-9 (March 1976).

112. Pollution Engineering, Inventory of Intermediate-Size Incinerators in the United States, 1972 (November 1973).

113. McColgan, I.J., Air Pollution Emissions and Control Technology: Packaged Incinerators, Environment Canada, Report EPS 3-AP-77-3 (October 1977).

114. Environment Canada, Combustion Technology for the Disposal and Utilization of Wood Residue, Report EPS 3-AP-75-4 (May 1975).

115. Statistics Canada, Canadian Forestry Statistics, Publication No. 25-202 (1978).

116. U.S. Environmental Protection Agency, National Emission Inventory of Sources and Emissions of Phosphorus, EPA 450/3-74-013 (May 1973).

117. Lee, R.E., and Lewis, R.G., Air Pollution from Pesticides: Sources, Occurrence and Dispersion, Air Pollution from Pesticides and Agricultural Processes, CRC Press Inc. Cleveland, Ohio (1976).

118. Statistics Canada Imports by Commodities, December 1978, Publication No. 65-007.

119. Industry, Trade and Commerce (Personal communication).

120. Environment Canada, Forest Fire Research Institute (unpublished information).

121. USDA Forest Service, An Update on Particulate Emissions from Forest Fires.

122. Statistics Canada, Canada Year Book, (1978-79).

123. Statistics Canada, Paint and Varnish Manufacturers, Publication No. 46-210 (1978).

124. Statistics Canada, Industries, Industry Division by Sex, for Canada, Provinces and Census Divisions, Publication No. 94-741, Vol: III Part: 4 (1971 Census of Canada).

125. Department of Public Works, Report of the Dominion Fire Commissioner, Fire Losses in Canada (1978).

126. Statistics Canada, Production and Disposition of Tobacco Products, Publication No. 32-022 (January - December 1978).

127. U.S. Department of Health, Education and Welfare, Public Exposure to Air Pollution from Tobacco Smoke (1972).

128. Bombarger, D.C. and Fowler, D.P., Pesticide Emissions - Manufacturing, Application and Disposal, Emission Factors and Inventories, Air Pollution Control Association (1979).

129. U.S. Environmental Protection Agency, Preliminary Scoring of Selected Organic Air Pollutants, (PB-264-442).

130. Canadian Petroleum, Canadian Petrochemical Plants, April 1979.

131. Statistics Canada, Bakeries, Publication No. 32-203, 1978.

132. Madison's Canadian Lumber Directory, 1980-1981.

133. Environmental Application Group Ltd., National Inventory of Anthropogenic Sources and Emissions of Organic Compounds 1976, Prepared for Environment Canada, March 1981.

134. Choquette, P.J., Air Pollution Emissions and Control Technology, Metallurgical Coke Manufacturing Industry, Environment Canada, Report EPS 3-AP-74-6 (November, 1974)

135. Statistics Canada, Crude Petroleum and Natural Gas Production, Publication No. 26-006 (December 1978).

136. Statistics Canada, Plastics Fabricating Industry, Publication No. 47-208, 1978.

APPENDIX A

TABLE A-1 EMISSIONS OF AIR CONTAMINANTS, NEWFOUNDLAND, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	48 570	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	-	-	-	-	-
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	4	-	-	-	1
Magnesium production	-	-	-	-	-
Asbestos production	3 013	-	-	-	-
Mining and rock quarrying	10 423	-	-	-	-
Salt production	-	-	-	-	-
Lime manufacturing	-	-	-	-	-
Gypsum processing	575	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica Processing	13	-	-	-	-
Stone processing	166	-	-	-	-
Sand and gravel processing	231	-	-	-	-
Cement manufacture	663	-	-	-	-
Concrete batching	26	-	-	-	-
Asphalt production	1 144	-	-	-	-
Glass manufacturing	-	-	-	-	-

TABLE A-1 EMISSIONS OF AIR CONTAMINANTS, NEWFOUNDLAND, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Clay products manufacture	70	-	-	-	-
Crude oil production	-	-	-	172	-
Petroleum refining	31	5 513	179	17 403	34 621
Natural gas processing	-	-	-	-	-
Tar sands operations	-	-	-	-	-
Coal industry	-	-	-	-	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical Industry	-	-	-	-	-
Plastics Fabrication	-	-	-	-	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	-	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	59	-	-	-	-
Phosphate fertilizer manufacture	-	-	-	-	-
Elemental phosphorus production	7 121	1 377	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	-	-	-	-	-
Bakeries	-	-	-	46	-
Sulphate (kraft) pulping	-	-	-	-	-
Sulphite pulping	-	3 269	-	-	-
Sawmills	-	-	-	-	-
Pulpboard manufacture	-	-	-	-	-
Plywood and Veneer	4	-	-	-	-
Subtotal	72 113	10 159	179	17 621	34 622

TABLE A-1 EMISSIONS OF AIR CONTAMINANTS, NEWFOUNDLAND, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
FUEL COMBUSTION/STATIONARY SOURCES					
Power generation by utilities	1 031	12 720	2 807	158	565
Residential fuel combustion	128	3 533	957	50	262
Industrial fuel combustion	1 936	26 854	6 346	84	363
Commercial fuel combustion	189	3 338	911	23	123
Fuelwood combustion	994	-	149	1 490	5 962
Subtotal	4 278	46 445	11 170	1 805	7 275
TRANSPORTATION					
Gasoline-powered motor vehicles	671	278	7 000	10 969	88 275
Railroads	21	163	309	77	113
Marine	178	525	556	1 206	2 996
Aircraft	53	87	1 461	296	1 703
Off-road use of gasoline	17	13	276	488	9 188
Diesel-powered engines	584	764	9 151	942	2 727
Tire wear	49	-	-	10	-
Subtotal	1 546	1 830	18 753	13 988	105 002
SOLID WASTE INCINERATION					
Municipal incineration	-	-	-	-	-
Industrial and commercial incineration	18	11	12	4	13
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	76	1	7	76	900
Subtotal	94	12	19	80	913

TABLE A-1 EMISSIONS OF AIR CONTAMINANTS, NEWFOUNDLAND, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
MISCELLANEOUS					
Fertilizer application	13	-	-	-	-
Pesticide manufacturing and application	3	-	-	-	-
Gasoline and diesel marketing	-	-	-	4 231	-
Dry cleaning	-	-	-	385	-
Application of surface coatings	-	-	-	1 936	-
Structural fires	66	-	-	66	132
Cigarette smoking	105	-	-	-	42
General Solvents Use	-	-	-	1 757	-
Landfill Sites	-	-	-	375	-
Forest Fires	7 722	-	206	1 236	8 237
Slash Burning	1 226	-	144	289	3 607
Subtotal	9 135	-	350	10 275	12 018
TOTAL	87 166	58 446	30 471	43 769	159 830

* Expressed as SO_2

** Expressed as NO_2

TABLE A-2 EMISSIONS OF AIR CONTAMINANTS, PRINCE EDWARD ISLAND, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	-	-	-	-	-
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	10	-	-	-	2
Magnesium production	-	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	-	-	-	-	-
Salt production	-	-	-	-	-
Lime manufacturing	-	-	-	-	-
Gypsum processing	-	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica Processing	-	-	-	-	-
Stone processing	-	-	-	-	-
Sand and gravel processing	44	-	-	-	-
Cement manufacture	-	-	-	-	-
Concrete batching	26	-	-	-	-
Asphalt production	1 630	-	-	-	-
Glass manufacturing	-	-	-	-	-

TABLE A-2 EMISSIONS OF AIR CONTAMINANTS, PRINCE EDWARD ISLAND, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Clay products manufacture	-	-	-	-	-
Crude oil production	-	-	-	-	-
Petroleum refining	-	-	-	-	-
Natural gas processing	-	-	-	-	-
Tar sands operations	-	-	-	-	-
Coal industry	-	-	-	-	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical Industry	-	-	-	-	-
Plastics Fabrication	-	-	-	-	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	-	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	-	-	-	-	-
Phosphate fertilizer manufacture	-	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	-	-	-	-	-
Bakeries	-	-	-	5	-
Sulphate (kraft) pulping	-	-	-	-	-
Sulphite pulping	-	-	-	-	-
Sawmills	-	-	-	-	-
Pulpboard manufacture	-	-	-	-	-
Plywood and Veneer	-	-	-	-	-
Subtotal	1 710	-	-	5	2

TABLE A-2 EMISSIONS OF AIR CONTAMINANTS, PRINCE EDWARD ISLAND, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
FUEL COMBUSTION/STATIONARY SOURCES					
Power generation by utilities	231	3 013	1 045	9	53
Residential fuel combustion	43	1 151	315	16	86
Industrial fuel combustion	31	444	114	2	9
Commercial fuel combustion	34	686	197	6	32
Fuelwood combustion	334	-	50	501	2 005
Subtotal	673	5 294	1 721	524	2 185
TRANSPORTATION					
Gasoline-powered motor vehicles	223	98	2 507	3 569	31 226
Railroads	9	66	126	32	46
Marine	5	16	15	10	14
Aircraft	4	5	105	27	297
Off-road use of gasoline	9	7	144	256	4 811
Diesel-powered engines	155	213	2 207	283	794
Tire wear	17	-	-	3	-
Subtotal	422	405	5 104	4 180	37 188
SOLID WASTE INCINERATION					
Municipal incineration	-	-	-	-	-
Industrial and commercial incineration	5	2	3	1	3
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	25	-	2	25	300
Subtotal	30	2	5	26	303

TABLE A-2 EMISSIONS OF AIR CONTAMINANTS, PRINCE EDWARD ISLAND, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
MISCELLANEOUS					
Fertilizer application	119	-	-	-	-
Pesticide manufacturing and application	195	-	-	-	-
Gasoline and diesel marketing	-	-	-	1 315	-
Dry cleaning	-	-	-	83	-
Application of surface coatings	-	-	-	437	-
Structural fires	54	-	-	54	107
Cigarette smoking	22	-	-	-	9
General Solvents Use	-	-	-	372	-
Landfill Sites	-	-	-	80	-
Forest Fires	333	-	9	53	356
Slash Burning	85	-	10	20	251
Subtotal	808	-	19	2 414	723
TOTAL	3 643	5 701	6 849	7 149	40 401

* Expressed as SO_2
** Expressed as NO_2

TABLE A-3 EMISSIONS OF AIR CONTAMINANTS, NOVA SCOTIA, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	23 555	605	-	-	-
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	162	-	-	-	28
Magnesium production	-	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	4 072	-	-	-	-
Salt production	1 452	-	-	-	-
Lime manufacturing	-	-	-	-	-
Gypsum processing	316	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	18	-	-	-	-
Stone processing	752	-	-	-	-
Sand and gravel processing	453	-	-	-	-
Cement manufacture	199	-	-	-	-
Concrete batching	45	-	-	-	-
Asphalt production	3 468	-	-	-	-
Glass manufacturing	-	-	-	-	-

TABLE A-3 EMISSIONS OF AIR CONTAMINANTS, NOVA SCOTIA, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Clay products manufacture	480	-	-	-	-
Crude oil production	-	-	-	2 312	-
Petroleum refining	1 182	10 147	347	16 058	66 966
Natural gas processing	-	-	-	-	-
Tar sands operations	-	-	-	-	-
Coal industry	274	-	-	12 698	-
Metallurgical coke manufacture	1 748	2 755	2	115	152
Petrochemical Industry	-	-	-	573	-
Plastics Fabrication	-	-	-	243	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	-	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	-	-	-	-	-
Phosphate fertilizer manufacture	-	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	200	-	-	-	-
Bakeries	-	-	-	114	-
Sulphate (kraft) pulping	4 195	518	351	191	413
Sulphite pulping	507	5 261	-	-	-
Sawmills	575	-	-	-	-
Pulpboard manufacture	-	-	-	-	-
Plywood and Veneer	-	-	-	-	-
Subtotal	43 653	19 286	700	32 304	67 559

TABLE A-3 EMISSIONS OF AIR CONTAMINANTS, NOVA SCOTIA, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
FUEL COMBUSTION/STATIONARY SOURCES					
Power generation by utilities	10 675	112 983	39 851	313	1 252
Residential fuel combustion	770	10 308	2 302	538	2 496
Industrial fuel combustion	2 079	30 761	6 783	542	1 485
Commercial fuel combustion	628	9 650	2 461	47	243
Fuelwood combustion	1 843	-	276	2 764	11 056
Subtotal	15 995	163 702	51 673	4 204	16 532
TRANSPORTATION					
Gasoline-powered motor vehicles	1 382	617	15 602	22 178	194 717
Railroads	208	1 607	3 058	765	1 112
Marine	80	508	308	731	1 911
Aircraft	34	61	1 078	213	1 196
Off-road use of gasoline	30	22	478	847	15 944
Diesel-powered engines	785	1 190	11 925	1 523	4 456
Tire wear	108	-	-	22	-
Subtotal	2 627	4 005	32 449	26 279	219 336
SOLID WASTE INCINERATION					
Municipal incineration	-	-	-	-	-
Industrial and commercial incineration	37	3	24	7	27
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	301	3	27	301	3 560
Subtotal	338	26	51	308	3 587

TABLE A-3 EMISSIONS OF AIR CONTAMINANTS, NOVA SCOTIA, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
MISCELLANEOUS					
Fertilizer application	79	-	-	-	-
Pesticide manufacturing and application	72	-	-	-	-
Gasoline and diesel marketing	-	-	-	8 250	-
Dry cleaning	-	-	-	569	-
Application of surface coatings	-	-	-	3 016	-
Structural fires	205	-	-	205	409
Cigarette smoking	155	-	-	-	62
General Solvents Use	-	-	-	2 610	-
Landfill Sites	-	-	-	554	-
Forest Fires	1 219	-	33	195	1 301
Slash Burning	2 228	-	262	524	6 553
Subtotal	3 958	-	295	15 923	8 263
TOTAL	66 571	187 019	85 168	79 018	315 277

* Expressed as SO_2
** Expressed as NO_2

TABLE A-4 EMISSIONS OF AIR CONTAMINANTS, NEW BRUNSWICK, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	-	-	-	-	-
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	1 099	15 580	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	486	-	-	-	128
Magnesium production	-	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	8 033	-	-	-	-
Salt production	-	-	-	-	-
Lime manufacturing	989	-	-	-	-
Gypsum processing	392	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	-	-	-	-	-
Stone processing	1 604	-	-	-	-
Sand and gravel processing	272	-	-	-	-
Cement manufacture	302	-	-	-	-
Concrete batching	45	-	-	-	-
Asphalt production	4 361	-	-	-	-
Glass manufacturing	33	-	-	-	-

TABLE A-4 EMISSIONS OF AIR CONTAMINANTS, NEW BRUNSWICK, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Clay products manufacture	193	-	-	-	-
Crude oil production	-	-	-	2 030	-
Petroleum refining***	-	-	-	-	-
Natural gas processing	-	-	-	-	-
Tar sands operations	-	-	-	-	-
Coal industry	379	-	-	1 329	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical Industry	-	-	-	-	-
Plastics Fabrication	-	-	-	194	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	-	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	22	-	-	-	-
Phosphate fertilizer manufacture	336	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	119	-	-	-	-
Bakeries	-	-	-	91	-
Sulphate (kraft) pulping	8 913	1 507	991	790	1 183
Sulphite pulping	-	8 674	-	-	-
Sawmills	1 273	-	-	-	-
Pulpboard manufacture	107	-	-	9	-
Plywood and Veneer	65	-	-	2	-
Subtotal	29 023	25 761	991	4 445	1 311

TABLE A-4 EMISSIONS OF AIR CONTAMINANTS, NEW BRUNSWICK, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
FUEL COMBUSTION/STATIONARY SOURCES					
Power generation by utilities	5 747	85 653	17 325	190	921
Residential fuel combustion	217	5 504	1 475	85	439
Industrial fuel combustion	3 338	44 876	9 766	315	449
Commercial fuel combustion	313	5 169	1 366	30	162
Fuelwood combustion	1 843	-	276	2 764	11 056
Subtotal	11 458	141 202	30 208	3 384	13 027
TRANSPORTATION					
Gasoline-powered motor vehicles	1 114	489	12 382	17 795	153 756
Railroads	160	1 234	2 349	587	854
Marine	42	215	152	506	1 362
Aircraft	33	48	721	256	4 344
Off-road use of gasoline	48	36	767	1 360	25 585
Diesel-powered engines	756	1 031	11 196	1 325	3 787
Tire wear	87	-	-	17	-
Subtotal	2 240	3 053	27 567	21 846	189 688
SOLID WASTE INCINERATION					
Municipal incineration	-	-	-	-	-
Industrial and commercial incineration	29	17	19	6	21
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	629	6	57	629	7 430
Subtotal	658	23	76	635	7 451

TABLE A-4 EMISSIONS OF AIR CONTAMINANTS, NEW BRUNSWICK, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
MISCELLANEOUS					
Fertilizer application	129	-	-	-	-
Pesticide manufacturing and application	152	-	-	-	-
Gasoline and diesel marketing	-	-	-	7 621	-
Dry cleaning	-	-	-	470	-
Application of surface coatings	-	-	-	2 443	-
Structural fires	127	-	-	127	254
Cigarette smoking	127	-	-	-	51
General Solvents Use	-	-	-	2 133	-
Landfill Sites	-	-	-	457	-
Forest Fires	4 351	-	116	696	4 641
Slash Burning	4 560	-	537	1 073	13 413
Subtotal	9 446	-	653	15 020	18 359
TOTAL	52 825	170 039	59 495	45 330	229 836

* Expressed as SO_2
** Expressed as NO_2
*** Included under Newfoundland

TABLE A-5 EMISSIONS OF AIR CONTAMINANTS, QUEBEC, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	59 823	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	16 230	8 667	-	-	215 368
Primary aluminum production	47 785	45 953	6 253	1 016	108 991
Primary copper and nickel production	19 060	575 360	-	-	-
Copper and nickel refining	45	-	-	-	-
Primary lead and zinc production	2 435	12 732	-	-	-
Ferroalloy manufacture	25 368	1 774	-	-	15 754
Abrasives manufacture	2 721	3 731	-	-	1 872
Ferrous foundries	3 975	-	-	-	988
Magnesium production	-	-	-	-	-
Asbestos production	63 879	-	-	-	-
Mining and rock quarrying	60 002	-	-	-	-
Salt production	-	-	-	-	-
Lime manufacturing	6 875	-	-	-	-
Gypsum processing	4 319	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	271	-	-	-	-
Stone processing	18 518	-	-	-	-
Sand and gravel processing	3 589	-	-	-	-
Cement manufacture	35 618	-	-	-	-
Concrete batching	494	-	-	-	-
Asphalt production	20 079	-	-	-	-
Glass manufacturing	329	-	-	-	-

TABLE A-5 EMISSIONS OF AIR CONTAMINANTS, QUEBEC, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Clay products manufacture	2 995	-	-	-	-
Crude oil production	-	-	-	1 234	-
Petroleum refining	3 812	23 834	1 180	73 445	115 221
Natural gas processing	-	-	-	-	-
Tar sands operations	-	-	-	-	-
Coal industry	-	-	-	-	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical Industry	-	-	-	12 919	-
Plastics Fabrication	-	-	-	4 905	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	1 455	-	-	-
Nitric acid production	-	-	399	-	-
Phosphoric acid production	71	-	-	-	-
Phosphate rock processing	15	-	-	-	-
Phosphate fertilizer manufacture	-	-	-	-	-
Elemental phosphorus production	3 554	738	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	7 451	-	-	-	-
Bakeries	-	-	-	1 226	-
Sulphate (kraft) pulping	17 971	3 781	2 451	1 910	2 945
Sulphite pulping	324	34 940	-	-	-
Sawmills	10 367	-	-	-	-
Pulpboard manufacture	364	-	-	29	-
Plywood and Veneer	590	-	-	21	-
Subtotal	438 929	712 965	10 283	96 705	461 139

TABLE A-5 EMISSIONS OF AIR CONTAMINANTS, QUEBEC, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydrocarbons	Carbon monoxide
FUEL COMBUSTION/STATIONARY SOURCES					
Power generation by utilities	314	1 959	2 366	211	692
Residential fuel combustion	2 496	50 142	13 849	618	3 030
Industrial fuel combustion	23 422	246 793	60 970	1 979	3 534
Commercial fuel combustion	3 931	60 551	16 450	367	1 776
Fuelwood combustion	18 165	-	2 725	27 247	108 988
Subtotal	48 328	359 445	96 360	30 422	118 020
TRANSPORTATION					
Gasoline-powered motor vehicles	9 442	4 006	100 598	147 756	1 227 224
Railroads	771	5 429	11 333	2 833	4 121
Marine	2 527	28 844	13 212	5 896	9 904
Aircraft	259	409	6 781	1 573	14 101
Off-road use of gasoline	61	46	974	1 726	32 482
Diesel-powered engines	6 113	7 314	88 377	9 349	26 102
Tire wear	730	-	-	146	-
Subtotal	19 903	46 048	221 275	169 279	1 313 934
SOLID WASTE INCINERATION					
Municipal incineration	2 443	735	834	420	9 995
Industrial and commercial incineration	286	172	187	57	207
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	5 091	46	463	5 091	60 170
Subtotal	7 820	953	1 484	5 568	70 372

TABLE A-5 EMISSIONS OF AIR CONTAMINANTS, QUEBEC, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
MISCELLANEOUS					
Fertilizer application	869	-	-	-	-
Pesticide manufacturing and application	625	-	-	-	-
Gasoline and diesel marketing	-	-	-	57 203	-
Dry cleaning	-	-	-	4 222	-
Application of surface coatings	-	-	-	33 721	-
Structural fires	1 745	-	-	1 745	3 490
Cigarette smoking	1 169	-	-	-	468
General Solvents Use	-	-	-	19 639	-
Landfill Sites	-	-	-	4 105	-
Forest Fires	6 059	-	162	969	6 463
Slash Burning	18 264	-	2 149	4 298	53 719
Subtotal	28 731	-	2 311	125 902	64 140
TOTAL	543 711	1 119 411	331 713	427 876	2 027 605

* Expressed as SO_2

** Expressed as NO_2

TABLE A-6 EMISSIONS OF AIR CONTAMINANTS, ONTARIO, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	30 515	151 550	-	-	38 104
Pyrrhotite roasting	2 369	26 171	-	-	-
Iron and steel production	32 371	1 817	-	-	31 700
Primary aluminum production	-	-	-	-	
Primary copper and nickel production	13 697	657 858	-	-	-
Copper and nickel refining	1 987	833	-	-	-
Primary lead and zinc production	608	1 530	-	-	-
Ferroalloy manufacture	1	8	-	-	-
Abrasives manufacture	4 810	4 142	-	-	4 852
Ferrous foundries	4 674	-	-	-	5 011
Magnesium production	329	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	33 550	-	-	-	-
Salt production	7 219	-	-	-	-
Lime manufacturing	15 071	-	-	-	-
Gypsum processing	6 536	-	-	-	-
Nepheline syenite processing	460	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	406	-	-	-	-
Stone processing	13 003	-	-	-	-
Sand and gravel processing	3 992	-	-	-	-
Cement manufacture	1 865	-	-	-	-
Concrete batching	853	-	-	-	-
Asphalt production	14 298	-	-	-	-
Glass manufacturing	839	-	-	-	-

TABLE A-6 EMISSIONS OF AIR CONTAMINANTS, ONTARIO, 1978
(continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Clay products manufacture	7 325	-	-	-	-
Crude oil production	-	-	-	29	-
Petroleum refining	3 391	36 727	1 660	30 435	104 500
Natural gas processing	-	186	-	22	-
Tar sands operations	-	-	-	-	-
Coal industry	427	-	-	-	-
Metallurgical coke manufacture	17 222	4 473	18	1 406	1 286
Petrochemical Industry	-	-	-	67 986	-
Plastics Fabrication	-	-	-	10 270	-
Carbon black	18	2 490	-	111	161 061
Sulphuric acid production	-	4 194	-	-	-
Nitric acid production	-	-	1 249	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	79	-	-	-	-
Phosphate fertilizer manufacture	708	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	2 850	-	77	-	-
Grain handling and milling	15 488	-	-	-	-
Bakeries	-	-	-	1 423	-
Sulphate (kraft) pulping	18 275	4 777	3 248	2 537	3 823
Sulphite pulping	271	13 029	-	-	-
Sawmills	5 240	-	-	-	-
Pulpboard manufacture	828	-	-	66	-
Plywood and Veneer	1 085	-	-	38	-
Subtotal	262 670	909 785	6 252	114 323	350 337

TABLE A-6 EMISSIONS OF AIR CONTAMINANTS, ONTARIO, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
FUEL COMBUSTION/STATIONARY SOURCES					
Power generation by utilities	13 468	437 740	91 867	1 434	5 049
Residential fuel combustion	2 230	22 498	16 286	1 137	4 195
Industrial fuel combustion	18 310	176 367	72 945	2 095	4 901
Commercial fuel combustion	2 109	22 560	14 860	637	2 117
Fuelwood combustion	10 740	-	1 611	16 110	64 439
Subtotal	46 857	659 165	197 569	21 413	80 701
TRANSPORTATION					
Gasoline-powered motor vehicles	14 742	6 411	161 631	230 077	1 975 256
Railroads	1 914	9 997	28 126	7 031	10 228
Marine	1 457	16 869	10 879	12 754	30 853
Aircraft	357	577	9 627	2 384	26 095
Off-road use of gasoline	272	205	4 382	7 765	146 127
Diesel-powered engines	7 181	10 230	110 237	13 095	37 608
Tire wear	1 155	-	-	231	-
Subtotal	27 078	44 289	324 882	273 337	2 226 167
SOLID WASTE INCINERATION					
Municipal incineration	635	469	543	273	6 430
Industrial and commercial incineration	448	269	293	90	322
Sewage sludge incineration	107	581	174	44	-
Wigwam burners	2 574	23	234	2 574	30 420
Subtotal	3 764	1 342	1 244	2 981	37 172

TABLE A-6 EMISSIONS OF AIR CONTAMINANTS, ONTARIO, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
MISCELLANEOUS					
Fertilizer application	1 994	-	-	-	-
Pesticide manufacturing and application	3 804	-	-	-	-
Gasoline and diesel marketing	-	-	-	84 123	-
Dry cleaning	-	-	-	5 707	-
Application of surface coatings	-	-	-	58 097	-
Structural fires	2 267	-	-	2 267	4 534
Cigarette smoking	1 550	-	-	-	620
General Solvents Use	-	-	-	26 033	-
Landfill Sites	-	-	-	5 549	-
Forest Fires	12 415	-	331	1 986	13 242
Slash Burning	10 819	-	1 273	2 546	31 821
Subtotal	32 849	-	1 604	186 308	50 217
TOTAL	373 218	1 614 581	531 551	598 362	2 744 594

* Expressed as SO_2

** Expressed as NO_2

TABLE A-7 EMISSIONS OF AIR CONTAMINANTS, MANITOBA, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro- carbons	Carbon monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	432	-	-	-	1 017
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	16 441	471 765	-	-	-
Copper and nickel refining	15	-	-	-	-
Primary lead and zinc production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	1 508	-	-	-	85
Magnesium production	-	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	3 837	-	-	-	-
Salt production	66	-	-	-	-
Lime manufacturing	2 313	-	-	-	-
Gypsum processing	1 295	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	189	-	-	-	-
Stone processing	692	-	-	-	-
Sand and gravel processing	748	-	-	-	-
Cement manufacture	2 487	-	-	-	-
Concrete batching	62	-	-	-	-
Asphalt production	3 963	-	-	-	-
Glass manufacturing	-	-	-	-	-

TABLE A-7 EMISSIONS OF AIR CONTAMINANTS, MANITOBA, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Clay products manufacture	42	-	-	-	-
Crude oil production	-	-	-	183	-
Petroleum refining	241	2 203	71	4 953	13 666
Natural gas processing	-	-	-	-	-
Tar sands operations	-	-	-	-	-
Coal industry	1 656	-	-	-	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical Industry	-	-	-	3 735	-
Plastics Fabrication	-	-	-	728	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	374	-	-	-
Nitric acid production	-	-	584	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	-	-	-	-	-
Phosphate fertilizer manufacture	271	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	640	-	20	-	-
Grain handling and milling	6 952	-	-	-	-
Bakeries	-	-	-	139	-
Sulphate (kraft) pulping	740	311	211	165	249
Sulphite pulping	-	834	-	-	-
Sawmills	-	-	-	-	-
Pulpboard manufacture	-	-	-	-	-
Plywood and Veneer	-	-	-	-	-
Subtotal	44 590	475 487	886	9 903	15 017

TABLE A-7 EMISSIONS OF AIR CONTAMINANTS, MANITOBA, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
FUEL COMBUSTION/STATIONARY SOURCES					
Power generation by utilities	7 084	3 773	3 675	139	457
Residential fuel combustion	202	1 295	1 468	126	413
Industrial fuel combustion	2 198	7 541	4 401	180	391
Commercial fuel combustion	1 247	2 202	2 328	141	353
Fuelwood combustion	1 210	-	180	1 802	7 208
Subtotal	11 941	14 811	12 052	2 388	8 822
TRANSPORTATION					
Gasoline-powered motor vehicles	2 173	953	24 096	34 963	300 951
Railroads	833	5 672	12 235	3 059	4 449
Marine	1	10	10	1 432	4 211
Aircraft	78	122	2 059	454	3 411
Off-road use of gasoline	235	177	3 784	6 706	126 195
Diesel-powered engines	1 719	2 237	23 309	3 094	8 352
Tire wear	167	-	-	33	-
Subtotal	5 206	9 171	65 493	49 741	447 569
SOLID WASTE INCINERATION					
Municipal incineration	1 687	121	142	71	1 669
Industrial and commercial incineration	49	29	31	10	35
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	168	2	15	168	1 986
Subtotal	1 904	152	188	249	3 690

TABLE A-7 EMISSIONS OF AIR CONTAMINANTS, MANITOBA, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
MISCELLANEOUS					
Fertilizer application	1 026	-	-	-	-
Pesticide manufacturing and application	5 140	-	-	-	-
Gasoline and diesel marketing	-	-	-	4 569	-
Dry cleaning	-	-	-	694	-
Application of surface coatings	-	-	-	3 871	-
Structural fires	510	-	-	510	1 021
Cigarette smoking	192	-	-	-	77
General Solvents Use	-	-	-	3 218	-
Landfill Sites	-	-	-	675	-
Forest Fires	40 607	-	1 083	6 497	43 314
Slash Burning	966	-	114	227	2 842
Subtotal	48 441	-	1 197	20 261	47 254
TOTAL	112 082	499 621	79 816	82 542	522 352

* Expressed as SO_2

** Expressed as NO_2

TABLE A-8 EMISSIONS OF AIR CONTAMINANTS, SASKATCHEWAN, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	2 053	-	-	-	3 431
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	29	-	-	-	5
Magnesium production	-	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	2 310	-	-	-	-
Salt production	681	-	-	-	-
Lime manufacturing	-	-	-	-	-
Gypsum processing	777	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Potash processing	22 802	-	-	-	-
Silica processing	62	-	-	-	-
Stone processing	-	-	-	-	-
Sand and gravel processing	463	-	-	-	-
Cement manufacture	1 497	-	-	-	-
Concrete batching	110	-	-	-	-
Asphalt production	4 932	-	-	-	-
Glass manufacturing	-	-	-	-	-

TABLE A-8 EMISSIONS OF AIR CONTAMINANTS, SASKATCHEWAN, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Clay products manufacture	355	-	-	-	-
Crude oil production	-	-	-	2 945	-
Petroleum refining	551	1 712	94	14 408	-
Natural gas processing	-	255	-	53	-
Tar sands operations	-	-	-	-	-
Coal industry	3 342	-	-	21 439	-
Metallurgical coke manufacture	310	318	2	77	67
Petrochemical Industry	-	-	-	-	-
Plastics Fabrication	-	-	-	291	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	674	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	-	-	-	-	-
Phosphate fertilizer manufacture	-	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	17 640	-	-	-	-
Bakeries	-	-	-	84	-
Sulphate (kraft) pulping	4 465	691	470	367	553
Sulphite pulping	-	-	-	-	-
Sawmills	717	-	-	-	-
Pulpboard manufacture	132	-	-	11	-
Plywood and Veneer	141	-	-	5	-
Subtotal	63 369	3 650	566	39 680	4 056

TABLE A-8 EMISSIONS OF AIR CONTAMINANTS, SASKATCHEWAN, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
FUEL COMBUSTION/STATIONARY SOURCES					
Power generation by utilities	64 453	36 998	37 697	756	2 568
Residential fuel combustion	315	1 688	2 000	214	740
Industrial fuel combustion	1 661	6 692	7 073	177	475
Commercial fuel combustion	96	178	1 143	74	196
Fuelwood combustion	1 409	-	211	2 114	8 455
Subtotal	67 934	45 556	48 124	3 335	12 434
TRANSPORTATION					
Gasoline-powered motor vehicles	2 643	1 229	31 318	43 569	399 162
Railroads	481	1 096	7 067	1 767	2 570
Marine	-	7	8	1 276	3 754
Aircraft	44	67	1 081	302	3 708
Off-road use of gasoline	461	346	7 417	13 143	247 325
Diesel-powered engines	4 156	4 744	48 750	7 031	17 902
Tire wear	206	-	-	41	-
Subtotal	7 991	7 489	95 641	67 129	674 421
SOLID WASTE INCINERATION					
Municipal incineration	124	22	18	9	251
Industrial and commercial incineration	36	21	24	7	26
Sewage sludge incineration	4	1	5	1	-
Wigwam burners	328	3	30	328	3 881
Subtotal	492	47	77	345	4 158

TABLE A-8 EMISSIONS OF AIR CONTAMINANTS, SASKATCHEWAN, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
MISCELLANEOUS					
Fertilizer application	973	-	-	-	-
Pesticide manufacturing and application	9 797	-	-	-	-
Gasoline and diesel marketing	-	-	-	12 954	-
Dry cleaning	-	-	-	642	-
Application of surface coatings	-	-	-	3 473	-
Structural fires	239	-	-	239	477
Cigarette smoking	173	-	-	-	69
General Solvents Use	-	-	-	2 902	-
Landfill Sites	-	-	-	624	-
Forest Fires	152 714	-	4 072	24 434	162 895
Slash Burning	1 534	-	181	361	4 513
Subtotal	165 430	-	4 253	45 629	167 954
TOTAL	305 216	56 742	148 661	156 118	863 023

* Expressed as SO_2

** Expressed as NO_2

TABLE A-9 EMISSIONS OF AIR CONTAMINANTS, ALBERTA, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	573	-	-	-	1 969
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	680	-	-	-	281
Magnesium production	-	-	-	-	-
Asbestos production	-	-	-	-	-
Mining and rock quarrying	790	-	-	-	-
Salt production	725	-	-	-	-
Lime manufacturing	2 424	-	-	-	-
Gypsum processing	2 331	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	99	-	-	-	-
Stone processing	229	-	-	-	-
Sand and gravel processing	1 216	-	-	-	-
Cement manufacture	4 085	-	-	-	-
Concrete batching	342	-	-	-	-
Asphalt production	3 217	-	-	-	-
Glass manufacturing	70	-	-	-	-

TABLE A-9 EMISSIONS OF AIR CONTAMINANTS, ALBERTA, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Clay products manufacture	865	-	-	-	-
Crude oil production	-	-	-	19 837	-
Petroleum refining	2 078	3 177	777	13 427	23 430
Natural gas processing	-	326 059	-	2 263	-
Tar sands operations	9 606	107 600	13 653	9	210
Coal industry	6 370	-	-	66 018	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical Industry	-	-	-	79 019	-
Plastics Fabrication	-	-	-	1 190	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	10 476	-	-	-
Nitric acid production	-	-	4 712	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	170	-	-	-	-
Phosphate fertilizer manufacture	2 688	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	3 207	-	73	-	-
Grain handling and milling	8 816	-	-	-	-
Bakeries	-	-	-	245	-
Sulphate (kraft) pulping	3 658	11 986	845	660	994
Sulphite pulping	-	-	-	-	-
Sawmills	1 977	-	-	-	-
Pulpboard manufacture	154	-	-	12	-
Plywood and Veneer	632	-	-	22	-
Subtotal	57 002	459 298	20 060	182 702	26 884

TABLE A-9 EMISSIONS OF AIR CONTAMINANTS, ALBERTA, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
FUEL COMBUSTION/STATIONARY SOURCES					
Power generation by utilities	59 814	35 073	35 764	1 216	4 371
Residential fuel combustion	1 852	2 117	3 847	1 714	7 050
Industrial fuel combustion	2 206	14 346	130 054	43 352	16 106
Commercial fuel combustion	494	260	5 883	389	984
Fuelwood combustion	921	-	138	1 382	5 528
Subtotal	65 287	51 796	175 686	48 053	34 039
TRANSPORTATION					
Gasoline-powered motor vehicles	4 800	2 175	55 142	76 940	688 373
Railroads	1 807	4 945	26 562	6 640	9 659
Marine	-	10	11	1 818	5 346
Aircraft	308	528	9 149	1 876	11 814
Off-road use of gasoline	560	421	9 021	15 985	300 802
Diesel-powered engines	6 031	7 166	81 149	9 872	26 177
Tire wear	379	-	-	76	-
Subtotal	13 885	15 245	181 034	113 207	1 042 171
SOLID WASTE INCINERATION					
Municipal incineration	-	-	-	-	-
Industrial and commercial incineration	82	49	53	16	59
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	1 096	10	100	1 096	12 957
Subtotal	1 178	59	153	1 112	13 016

TABLE A-9 EMISSIONS OF AIR CONTAMINANTS, ALBERTA, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro- carbons	Carbon monoxide
MISCELLANEOUS					
Fertilizer application	1 567	-	-	-	-
Pesticide manufacturing and application	6 687	-	-	-	-
Gasoline and diesel marketing	-	-	-	26 681	-
Dry cleaning	-	-	-	1 339	-
Application of surface coatings	-	-	-	6 797	-
Structural fires	867	-	-	867	1 733
Cigarette smoking	345	-	-	-	138
General Solvents Use	-	-	-	5 790	-
Landfill Sites	-	-	-	1 301	-
Forest Fires	12 855	-	343	2 057	13 712
Slash Burning	3 494	-	411	822	10 276
Subtotal	25 815	-	754	45 654	25 859
TOTAL	163 167	526 398	377 687	390 728	1 141 969

* Expressed as SO_2

** Expressed as NO_2

TABLE A-10 EMISSIONS OF AIR CONTAMINANTS, BRITISH COLUMBIA, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	1 261	-	-	-	-
Pyrrhotite roasting	250	5 390	-	-	-
Iron and steel production	568	-	-	-	1 271
Primary aluminum production	9 409	6 133	2 150	432	37 700
Primary copper and nickel production	37	2 441	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	4 376	21 648	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	534	-	-	-	186
Magnesium production	-	-	-	-	-
Asbestos production	5 580	-	-	-	-
Mining and rock quarrying	66 652	-	-	-	-
Salt production	-	-	-	-	-
Lime manufacturing	1 378	-	-	-	-
Gypsum processing	2 995	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	11	-	-	-	-
Stone processing	1 240	-	-	-	-
Sand and gravel processing	2 291	-	-	-	-
Cement manufacture	1 045	-	-	-	-
Concrete batching	204	-	-	-	-
Asphalt production	7 157	-	-	-	-
Glass manufacturing	140	-	-	-	-

TABLE A-10 EMISSIONS OF AIR CONTAMINANTS, BRITISH COLUMBIA, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Clay products manufacture	397	-	-	-	-
Crude oil production	-	-	-	667	-
Petroleum refining	1 233	9 901	435	15 805	62 870
Natural gas processing	-	108 391	-	10	-
Tar sands operations	-	-	-	-	-
Coal industry	67 017	-	-	52 412	-
Metallurgical coke manufacture	671	214	1	30	38
Petrochemical Industry	-	-	-	4 694	-
Plastics Fabrication	-	-	-	1 942	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	456	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	70	-	-	-	-
Phosphate fertilizer manufacture	298	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	8 384	-	-	-	-
Bakeries	-	-	-	374	-
Sulphate (kraft) pulping	47 503	11 670	7 933	6 135	9 342
Sulphite pulping	340	3 063	-	-	-
Sawmills	40 851	-	-	-	-
Pulpboard manufacture	185	-	-	15	-
Plywood and Veneer	5 810	-	-	206	-
Subtotal	277 887	169 307	10 519	82 722	111 407

TABLE A-10 EMISSIONS OF AIR CONTAMINANTS, BRITISH COLUMBIA, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
FUEL COMBUSTION/STATIONARY SOURCES					
Power generation by utilities	143	225	1 627	149	488
Residential fuel combustion	474	4 133	3 333	259	935
Industrial fuel combustion	4 121	48 226	21 487	1 073	1 319
Commercial fuel combustion	403	3 495	3 244	161	488
Fuelwood combustion	550	-	83	825	3 300
Subtotal	5 691	56 079	29 774	2 467	6 530
TRANSPORTATION					
Gasoline-powered motor vehicles	5 502	2 467	62 450	87 276	773 828
Railroads	684	2 174	10 048	2 512	3 654
Marine	374	1 083	1 177	4 147	11 046
Aircraft	216	327	5 215	1 487	18 046
Off-road use of gasoline	251	189	4 048	7 174	134 995
Diesel-powered engines	2 508	4 161	40 494	5 210	15 661
Tire wear	434	-	-	87	-
Subtotal	9 969	10 401	123 432	107 893	957 230
SOLID WASTE INCINERATION					
Municipal incineration	87	20	5	4	157
Industrial and commercial incineration	119	71	77	24	86
Sewage sludge incineration	22	3	5	2	Neg
Wigwam burners	19 883	181	1 808	19 883	234 980
Subtotal	20 111	275	1 895	19 913	235 223

TABLE A-10 EMISSIONS OF AIR CONTAMINANTS, BRITISH COLUMBIA, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
MISCELLANEOUS					
Fertilizer application	141	-	-	-	-
Pesticide manufacturing and application	241	-	-	-	-
Gasoline and diesel marketing	-	-	-	26 805	-
Dry cleaning	-	-	-	1 721	-
Application of surface coatings	-	-	-	14 410	-
Structural fires	670	-	-	670	1 339
Cigarette smoking	463	-	-	-	185
General Solvents Use	-	-	-	7 770	-
Landfill Sites	-	-	-	1 674	-
Forest Fires	82 637	-	2 204	13 222	88 146
Slash Burning	40 284	-	4 739	9 478	118 481
Subtotal	124 436	-	6 943	75 750	208 151
TOTAL	438 094	236 062	172 563	288 745	1 518 541

* Expressed as SO_2

** Expressed as NO_2

TABLE A-11 EMISSIONS OF AIR CONTAMINANTS, YUKON AND NORTHWEST TERRITORIES, 1978

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
INDUSTRIAL PROCESSES					
Iron ore mining and beneficiation	-	-	-	-	-
Pyrrhotite roasting	-	-	-	-	-
Iron and steel production	-	-	-	-	-
Primary aluminum production	-	-	-	-	-
Primary copper and nickel production	-	-	-	-	-
Copper and nickel refining	-	-	-	-	-
Primary lead and zinc production	-	-	-	-	-
Ferroalloy manufacture	-	-	-	-	-
Abrasives manufacture	-	-	-	-	-
Ferrous foundries	-	-	-	-	-
Magnesium production	-	-	-	-	-
Asbestos production	4 353	-	-	-	-
Mining and rock quarrying	3 140	-	-	-	-
Salt production	-	-	-	-	-
Lime manufacturing	-	-	-	-	-
Gypsum processing	-	-	-	-	-
Nepheline syenite processing	-	-	-	-	-
Potash processing	-	-	-	-	-
Silica processing	-	-	-	-	-
Stone processing	-	-	-	-	-
Sand and gravel processing	-	-	-	-	-
Cement manufacture	-	-	-	-	-
Concrete batching	-	-	-	-	-
Asphalt production	9	-	-	-	-
Glass manufacturing	-	-	-	-	-

TABLE A-11 EMISSIONS OF AIR CONTAMINANTS, YUKON AND NORTHWEST TERRITORIES, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
Clay products manufacture	-	-	-	-	-
Crude oil production	-	-	-	45	-
Petroleum refining	-	-	-	-	-
Natural gas processing	-	-	-	-	-
Tar sands operations	-	-	-	-	-
Coal industry	-	-	-	-	-
Metallurgical coke manufacture	-	-	-	-	-
Petrochemical Industry	-	-	-	-	-
Plastics Fabrication	-	-	-	-	-
Carbon black	-	-	-	-	-
Sulphuric acid production	-	-	-	-	-
Nitric acid production	-	-	-	-	-
Phosphoric acid production	-	-	-	-	-
Phosphate rock processing	-	-	-	-	-
Phosphate fertilizer manufacture	-	-	-	-	-
Elemental phosphorus production	-	-	-	-	-
Nitrate fertilizer manufacture	-	-	-	-	-
Grain handling and milling	-	-	-	-	-
Bakeries	-	-	-	2	-
Sulphate (kraft) pulping	-	-	-	-	-
Sulphite pulping	-	-	-	-	-
Sawmills	-	-	-	-	-
Pulpboard manufacture	-	-	-	-	-
Plywood and Veneer	-	-	-	-	-
Subtotal	7 503	-	-	47	-

TABLE A-11 EMISSIONS OF AIR CONTAMINANTS, YUKON AND NORTHWEST TERRITORIES, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
FUEL COMBUSTION/STATIONARY SOURCES					
Power generation by utilities	260	421	2 901	280	905
Residential fuel combustion	12	119	78	5	21
Industrial fuel combustion	22	343	195	9	39
Commercial fuel combustion	32	554	265	9	53
Fuelwood combustion	334	-	50	501	2 005
Subtotal	660	1 437	3 489	804	3 023
TRANSPORTATION					
Gasoline-powered motor vehicles	114	53	1 363	1 950	17 754
Railroads	15	85	220	55	80
Marine	1	3	3	2	3
Aircraft	44	53	729	226	2 572
Off-road use of gasoline	14	11	237	420	7 904
Diesel-powered engines	1 097	1 127	16 442	1 358	3 763
Tire wear	8	-	-	2	-
Subtotal	1 293	1 332	18 994	4 013	32 076
SOLID WASTE INCINERATION					
Municipal incineration	-	-	-	-	-
Industrial and commercial incineration	2	1	2	0	2
Sewage sludge incineration	-	-	-	-	-
Wigwam burners	9	-	1	9	111
Subtotal	11	1	3	9	113

TABLE A-11 EMISSIONS OF AIR CONTAMINANTS, YUKON AND NORTHWEST TERRITORIES, 1978 (continued)

	Emissions (tonnes)				
	Particulate matter	Sulphur oxides*	Nitrogen oxides**	Hydro-carbons	Carbon monoxide
MISCELLANEOUS					
Fertilizer application	-	-	-	-	-
Pesticide manufacturing and application	-	-	-	-	-
Gasoline and diesel marketing	-	-	-	698	-
Dry cleaning	-	-	-	44	-
Application of surface coatings	-	-	-	228	-
Structural fires	27	-	-	27	56
Cigarette smoking	12	-	-	-	5
General Solvents Use	-	-	-	203	-
Landfill Sites	-	-	-	43	-
Forest Fires	142 597	-	3 802	22 815	152 103
Slash Burning	90	-	11	21	263
Subtotal	142 726	-	3 813	24 079	152 427
TOTAL	152 193	2 770	26 299	28 952	187 639

* Expressed as SO_2

** Expressed as NO_2

APPENDIX B

OPEN SOURCES

Open sources are defined as those stationary sources of air pollution too great in extent to be controlled through enclosure or ducting. In this section, the major sectors of open sources are identified, and emission rates applicable to 1978 are estimated.

Recently open source emissions have been receiving increased attention, especially in the U.S., since the analysis of the particulate matter from ambient TSP (total suspended particulate) samplers revealed that at many sampling locations, the particles were originating from non-industrial sources (1, 2). Further investigations indicated that matter captured on filters taken from TSP samplers located in major cities was predominantly mineral matter and/or soil-like material. This inventory, intended to give an initial understanding of the origin of the soil-like material collected with TSP samplers determines the contribution of open sources to total atmospheric emission rates.

The reported emissions for open sources were calculated based on the best available inventory techniques. To date, published research in this area is limited while the difficulty in measuring emission rates from open sources is by far more difficult than from point sources. It should therefore be understood that the emission estimates are preliminary, but it is unlikely they are wrong by an order of magnitude (3); it can also be said with certainty that the emissions from these sources exceed the particulate emissions from point sources.

The estimated emissions are very large and account for more than 90 percent of the total anthropogenic particulate emissions (Tables B-1 and B-8). However, their impact on air quality is not well known (4). In addition, most of these emissions are generated in rural areas and their impact in populated areas would depend upon particle transport and relative toxicities which have not been precisely established.

B.1 Paved Roads

B.1.1 General. Fugitive particulate emissions result from vehicular activity on paved roads. The particulate matter on the road surface originates from road sanding operations, from adjacent road shoulders, and from wind blown silt. Vehicular activity also wears out the road surface material, the larger particles are eventually pulverized and become airborne with the other silt matter during subsequent vehicular activity and wind action. Only particulates smaller than 30 microns are considered since they remain suspended under dry and windy conditions and can be transported over long distances.

TABLE B-1 NATIONWIDE EMISSIONS OF PARTICULATE MATTER, 1978

Category	Particulate Emissions (tonnes x 10^3)	% of Total
Industrial Processes	1 298	3.0
Fuel Combustion/Stationary Sources	279	0.6
Transportation	92	0.2
Solid Waste Incineration	36	0.1
Miscellaneous	592	1.4
Open Sources	40 651	94.7
Total	42 948	100.0

B.1.2 **Controls.** Road sweeping and water spraying are effective methods in reducing road dust emissions. These methods are used mainly in large cities to reduce the nuisance caused by atmospheric dust particles. The frequency, as well as the period of effectiveness of these control measures is not known, hence no controls were assumed. Moreover a very small percentage of the total paved road surface is controlled.

B.1.3 **Emissions.** An estimated emission factor of 4.78 g/10^6 Veh-km was taken from an EPA publication (5). Emissions are also governed by the total vehicle miles travelled and the number of wheels per vehicle (vehicle mix). Total vehicle miles travelled by province, including travel on unpaved roads, was based on fuel consumptions obtained from Statistics Canada publication (6). A study done for the province of Saskatchewan (7) was used to estimate the percentage of vehicle miles travelled per road type for all provinces, provincial mileages for each type of road were taken into consideration (10). Data on vehicle mix was obtained from a Statistics Canada publication (8).

Emissions are summarized in Table B-2.

B.2 Unpaved Roads

B.2.1 **General.** Fugitive particulate emissions from unpaved roads are generated through a combination of vehicular traffic activity and wind action.

Unpaved roads are divided into three road types; treated and untreated gravel roads, and earth roads. Fugitive dust emissions evolve from the wheel action of a vehicle which pulverizes and lifts particulates from the road surface. Turbulent wind currents

TABLE B-2 TOTAL EMISSIONS, PAVED ROADS, 1978

	Emissions of particulate matter (tonnes)
Newfoundland	17 762
Prince Edward Island	5 543
Nova Scotia	34 754
New Brunswick	31 091
Quebec	247 801
Ontario	354 046
Manitoba	37 515
Saskatchewan	41 469
Alberta	99 537
British Columbia	120 615
Yukon, N.W.T.	1 644
TOTAL CANADA	991 777

caused by the moving vehicle disperse dust from wheels as well as surface dust from road. The amount of dust liberated is dependant on soil characteristics, meteorological conditions and average vehicle speed.

B.2.2 **Controls.** A dust control efficiency of 50 percent was applied to gravel roads treated with used oil or dust supressants such as calcium chloride ($CaCL_2$) (9). Little or no controls were used on earth roads. Restriction of vehicle speed is a potentially effective control, however no such implementation was assumed to be in effect.

B.2.3 **Emissions.** Dust emissions from unpaved roads were estimated using an empirical equation developed from actual test measurements (11). For each type of unpaved road surface, emissions were found to depend on the following factors: number of vehicle miles, average vehicle speed, number of wheels per vehicle, surface texture and surface moisture. Data on the number of vehicle miles by road type was evaluated as for paved roads. Average vehicle speed for gravel and earth roads was estimated based on an EPA document (12). Data on vehicle mix, surface texture and surface moisture were obtained from other external sources (8, 13, 14).

Emission are presented in Table B-3.

B.3 Agricultural Tilling

B.3.1 **General.** Tilling involves turning over the topsoil on agricultural land. This operation is performed several times a year. The amount of dust generated is influenced

TABLE B-3 TOTAL EMISSIONS, UNPAVED ROADS, 1978

	Emissions of particulate matter (tonnes)
Newfoundland	141 821
Prince Edward Island	24 072
Nova Scotia	431 728
New Brunswick	232 559
Quebec	1 475 156
Ontario	3 854 650
Manitoba	1 588 445
Saskatchewan	3 316 485
Alberta	4 321 792
British Columbia	1 047 451
Yukon, N.W.T.	240 949
TOTAL CANADA	16 675 108

by several variables; however, the three principal factors are: soil silt content, soil moisture and implement speed.

B.3.2 Emissions. Emission factors for Canadian conditions were developed using an equation obtained from a U.S. study (2) which relates the different parameters. Agricultural land area was obtained from a Statistics Canada publication (15). No dust control was assumed although emissions can be controlled by spraying the soil with dust suppressant chemicals.

Total emissions from agricultural tilling are presented in Table B-4.

TABLE B-4 TOTAL EMISSIONS, AGRICULTURAL TILLING, 1978

	Emissions of particulate matter (tonnes)
Newfoundland	14
Prince Edward Island	825
Nova Scotia	475
New Brunswick	722
Quebec	6 956
Ontario	23 289
Manitoba	74 920
Saskatchewan	664 634
Alberta	248 921
British Columbia	3 840
Yukon, N.W.T.	29
TOTAL CANADA	1 024 625

B.4 Agricultural Wind Erosion

B.4.1 General. Wind erosion of agricultural soils contributes significantly to overall fugitive dust emissions. The susceptibility of land to wind erosion is dependent on a number of variables such as climate, soil characteristics and vegetative cover.

B.4.2 Controls. The primary and most inexpensive method of dust control is the use of vegetative cover as a dust suppressant. Other forms of control such as chemical stabilization of the soil and limited irrigation of fallow fields provide approximate efficiencies of 40% and 20% respectively.

B.4.3 Emissions. Emission factors developed by the U.S. EPA (2, 16) for individual states were averaged and applied to Canadian provinces according to the state proximity and similar geographical conditions. Acreage of agricultural cropland was obtained from Canadian literature (15).

Total emissions from agricultural wind erosion are presented in Table B-5.

TABLE B-5 TOTAL EMISSIONS, AGRICULTURAL WIND EROSION, 1978

	Emissions of particulate matter (tonnes)
Newfoundland	43
Prince Edward Island	6 003
Nova Scotia	3 956
New Brunswick	5 629
Quebec	77 296
Ontario	506 291
Manitoba	169 793
Saskatchewan	1 517 669
Alberta	1 825 047
British Columbia	62 052
Yukon, N.W.T.	2
TOTAL CANADA	4 173 781

B.5 Construction Sites

B.5.1 General. Fugitive dust emissions from construction sites are the result of operations such as land clearing, blasting, ground excavation, cut and fill operations and travel on access roads and sites. Wind erosion contributes very little to the overall emissions.

B.5.2 Controls. Treatment of access roads and sites with water or oil results in an approximate control efficiency of 50%. Chemical treatment, although less feasible for short duration construction, will provide an efficiency in the area of 80%.

B.5.3 Emissions. The extent of construction activity was calculated based on construction expenditure in Canada (17). Conversion factors and duration of construction estimates along with an equation to estimate dust emissions were obtained from U.S. studies (2).

Total emissions from construction activity are presented in Table B-6.

TABLE B-6 TOTAL EMISSIONS, CONSTRUCTION SITES, 1978

	Emissions of particulate matter (tonnes)
Newfoundland	139 907
Prince Edward Island	44 747
Nova Scotia	528 443
New Brunswick	528 333
Quebec	5 654 789
Ontario	4 415 579
Manitoba	597 123
Saskatchewan	618 403
Alberta	2 695 798
British Columbia	2 499 659
Yukon, N.W.T.	
TOTAL CANADA	17 722 781

B.6 Mine Tailings

B.6.1 General. Concentrating minerals from their respective ores results in a solid waste which leaves the mill as a slurry. The slurry is channelled to a tailings pond where the solids settle out of suspension. When the pond is filled or is no longer in use, the water eventually drains away and/or is evaporated. The dry tailing matter is then susceptible to wind erosion.

B.6.2 Controls. Control methods generally used consist of vegetative cover and chemical stabilization. These controls are approximately 60 to 90 percent efficient.

B.6.3 **Emissions.** Emissions were calculated using acreage of tailings piles obtained from the Department of Energy, Mines and Resources and emission factors developed from an equation taken from U.S. studies (2, 18).

Total emissions from tailings piles are presented in Table B-7.

TABLE B-7 TOTAL EMISSIONS, MINE TAILINGS, 1978

	Emissions of particulate matter (tonnes)
Newfoundland	1 038
Prince Edward Island	
Nova Scotia	64
New Brunswick	560
Quebec	6 410
Ontario	9 601
Manitoba	4 744
Saskatchewan	15 279
Alberta	1 760
British Columbia	18 426
Yukon, N.W.T.	5 171
TOTAL CANADA	63 053

TABLE B-8 NATIONWIDE EMISSIONS OF PARTICULATE MATTER, FROM OPEN SOURCES, 1978

Source	Emissions (tonnes x 10^3) Particulate Matter
Paved Roads	991.8
Unpaved Roads	16 675.1
Agricultural Tilling	1 024.6
Agricultural Wind Erosion	4 173.8
Construction Activity	17 722.8
Mine Tailings	63.1
Total	40 651.2

REFERENCES

1. Edward, J.L. and Young, D., EPA Lacks At Fugitive Emissions, Journal of the Air Pollution Control Association, Vol. 25, No. 10 (October 1975).

2. Evans, J.S. and Cooper, D.W., An Inventory of Particulate Emissions from Open Sources, Journal of the Air Pollution Control Association, Vol. 30, No. 12 (December 1980).

3. U.S. Environmental Protection Agency, Priorities for Control of Fugitive Particulate Emissions from Open Sources, Cooper, D.W. et al., EPA-600/7-79-186 (August 1979).

4. U.S. Environmental Protection Agency, 1976 National Emissions Report, National Air Data Branch, EPA-450/4-79-019, (August 1979).

5. U.S. Environmental Protection Agency, Quantification of dust entrainment from paved roadways, EPA-450/3-77-027 (1977).

6. Statistics Canada, Road Motor Vehicles - Fuel Sales, Publication No. 53-218 (1978).

7. Saskatchewan Department of Highways and Transportation, Travel on Saskatchewan Highways 1980.

8. Statistics Canada, Road Motor Vehicles - Registration, Publication No. 53-219 (1978).

9. PACE, Recycling of Used Lubricating Oil as a Dust Suppressant, Report No. 76-7 (1976).

10. Statistics Canada, Road and Street Length and Financing, Publication No. 53-201 (1976).

11. Midwest Research Institute, Emissions Inventory of Agricultural Tilling, Unpaved Roads and Airstrips, and Construction Sites, U.S. EPA, Publication EPA-450/3-74-085 (November 1974).

12. PEDCO Environmental, Inc., Montana AQMA Area Source Emission Inventory, U.S. EPA, Publication No. EPA-908/1-76-005, December 1975.

13. Agriculture Canada, Soil Research Institute, (personal communication).

14. Atmospheric Environment Service, Monthly Record-Meteorological Observations, 1978.

15. Statistics Canada, Agriculture, Publication No. 96-800, (1978).

16. A Wind Erosion Equation, N.P. Woodruff, F.H. Siddoway, Soil Science Society Proceedings, 1965.

17. Statistics Canada, Construction in Canada, Publication No. 64-201, (1978).

18. Department of Energy, Mines and Resources, Pit Slope Manual, Supplement 10-1, Vol. 2 "Mine Waste Inventory by Satellite Imagery".